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Procedures for research vessel design

. C. TROUT
isheries Laboratory, Lowestoft

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ATES

v *Cirolana* (Crown copyright)

rv *Corella's* engines installed with gearbox on raft (solidly mounted test bed: (acknowledgement to W H Allen Sons and Company Ltd)

v *Corella's* engine installation, after end, to show flexible coupling cardan shaft (acknowledgement to W H Allen Sons and Company l)

rv *Cirolana's* raft sections awaiting erection (Crown copyright)

Net drum winch installed alongside main cable winch at boat deck el on RV *Cirolana*, below after bridge windows (Crown copyright)

rv *Cirolana:* main trawl winch, spooling by LeBus grooves on warp rrel (Crown copyright)

Double framing in area of maximum slamming (note after bulkhead bow propeller compartment) (Crown copyright)

Forward starboard conning position with aircraft astrodome, seen m after side of chart table (Crown copyright)

FIGURES

FIG. 1 R. Mitson's simplified underwater noise curve of RVs *Clione*, *Corella* and *Cirolana* (with acknowledgements to MOD(N) AUWE). (*Cirolana* curve of levels before treatment of propeller's trailing edge, etc.) 7

FIG. 2* General arrangement drawing of RV *Cirolana* in profile. Retractable bow thruster shown housed, with propeller forward (see also Figure 11).

FIG. 3* Layout of main and upper decks. When built, the Main Cable Winch was installed centrally, abaft Plotting Room (see Plate 5 of Net Drum and Main Cable Winches). Watertight doors in alley ways.

FIG. 4* Layout of lower (accommodation) deck and orlop deck.

FIG. 5* Plan of engine room showing extent of hood.

FIG. 6* Longitudinal section of engine room showing hood and raft support.

FIG. 7 Noise levels within *Cirolana's* lower deck cabin accommodation (published by kind permission of M. Hartnell-Beavis). 12

1 Adjacent to steering gear flat (student's cabin).

2 Deck above engine room aft end (second engineer's cabin).

3 Deck above engine room forward end (after scientist's cabin).

4 Forward 3-men cabin (ventilation on).

5 Forward 3-men cabin (ventilation off).

FIG. 8 Noise levels within *Cirolana's* mess and recreational areas. 12

1 Captain and scientists' mess (upper deck).

2 Captain and scientists' recreational room (upper deck).

3 Crew's mess (upper deck).

FIG. 9 Noise levels within *Cirolana's* wheelhouse, laboratories, radio room and hospital. 12

1 Hospital (boat deck).

2 Wet fish laboratory (upper deck).

3 Main laboratory.

4 Wheelhouse (centre).

5 Radio room (bridge deck).

FIG. 10 Self-noise levels at the terminals of *Cirolana's* 30 kHz hull-mounted transducer after propeller treatment and attention to streamlining detail (see text, page 36). 13

FIG. 11* The lines represent a hull with the following design characteristics: LBP=205.0 feet (62.5 m); beam moulded 46.0 feet (14.02 m); depth moulded=26.0 feet (7.93 m); C_b=0.520; C_p=0.601; LCB (aft) =5.57 feet (1.7 m aft); ½ angle of entrance=14.5°; length of entrance= 110.7 feet (33.77 m); length of run=94.3 feet (28.77 m).

FIG. 12 *Cirolana's* retractable and rotatable bow propeller and pod. Shown rotated, i.e. with propeller forward, and retracted. 14

FIG. 13* Plans of bridge, passive roll-stabiliser tank and radio room.

FIG. 14 Diagrammatic section through main trawl winch warp drum after strengthening (with acknowledgements to LeBus International Engineers Limited). 17

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*Throwouts

Abstract

This paper suggests an approach philosophy to be used during the compilation of a brief for the Consultant Naval Architect who is selected to undertake the integration of the complex design requirements for a modern fisheries research vessel.

The process of planning and building the Lowestoft Laboratory's *Cirolana* is used to illustrate some aspects of that approach and the outcome of some of the special measures taken.

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ıtroduction

though Fujinami (1968) listed 908 surface research vessels, which the United Kingdom accounted for 57, Japan 258 d the USA 226, most fishery research establishments oper- only a small fleet and are thus faced with the building of a w vessel relatively infrequently. In such a situation staff volvement tends to lack continuity from one building pro- t to the next. Experience of any particular aspect of plan- ng or building of earlier vessels will be buried in a plethora papers on many different files or in the memories of the aff, some of whom may no longer be in the establishment. ıe writer was concerned with the design and acquisition of ur of the Ministry's research vessels, *Ernest Holt* (Anon. 49, Graham *et al.* 1954), *Clione* (Anon. 1961), *Corella* non. 1967) and *Cirolana* (Trout and Downham 1968, non. 1970), operated by the Fisheries Laboratory, Lowe- oft, and has been to a greater or lesser extent involved with e design of more than twenty other vessels in several ountries; some experiences gained in the field of research ssel design and building may therefore be found of use to ıe research establishment faced with the need to procure a ew vessel. This does not mean that the writer considers the linistry's vessels are without fault or that the Ministry has llowed the only course of action. He is only too well aware f the vessels' imperfections but is convinced that some of ıem could have been avoided and that future vessels can be mproved. In the main, the possibilities for improvement lie ıore within the power of the user organization to control, ıore vigorously and with better understanding, the develop- ıent of the design and the details of the actual building con- ract, than in technical improvements in naval architecture nd marine engineering. The purpose of this paper, therefore, s to try to outline the philosophy of the approach to the lifferent stages, from agreement to build to completion of rials, and the ways of increasing the certainty of achieving he desired outcome of one of the most expensive exercises in vhich fisheries laboratories are involved. Some of the ideas were outlined in 1969 (Trout 1974).

The outcome of building a new research vessel affects the work of the laboratory in a number of ways and for a long period, not only by its initial cost, but also by its effectiveness, or otherwise, in operation, its updating and running costs. It is thought to be essential, therefore, that all aspects of the vessel requirements are considered by the users; not only research needs, but shore facilities at the home port, operation of maintenance programmes, dry-docking, support personnel and the like, so that operating the vessel at sea and in port can be carried out simply and conveniently to suit the needs of the scientific staff. Common-sense planning can achieve this.

The appendix contains some details of *Cirolana's* design and content; the author's original wish to publish this information was so that staff might be aware of the basic design aims and thus to be able to utilize the vessel more fully. It is also hoped that a fuller knowledge of what has been provided will ensure that later additions and alterations, always inevitable as research develops, should not reduce the potential of the overall concept.

The problem: The user's responsibility

Attitudes to design are varied. Often there is evidence of confusion over just what the term 'design' embraces: 'styling' and 'trim' are used as synonyms for 'design' in the car industry's sales brochures. In general, too, the public is conditioned to the acceptance of design—for they have no say in the design of cars, of builders' high-density housing schemes and high-rise flats—and must take them as they stand. On the whole, however, a sufficiently wide selection of car models is available, and flats and houses of varying size and accommodation, to provide for different family size and needs. Once these basic requirements are satisfied, acceptance of the design and planning imposed from outside follows. Admittedly, the most glaring faults have often been eliminated, and one gets used to the minor ones or may be able to rectify them if they persist in annoying.

In the clothing industry also, fashion is imposed by the designers, but sufficient variation occurs to permit personal selection of the most suitable commodity. However, in footwear the swing from the male 'winkle-picker' to 'bullnose' shoes, and from the female 'stiletto heels' to 'platform soles', could be acceptable only in terms of fashion and not as a result of logical, functional design in the normal accepted sense of that word.

The outcome of this conditioning is, therefore, a generally low level of critical interest in basic design requirements, and an attitude that one should not 'fuss' unduly to 'get things just right'. Thus there is a tendency to leave designing to the 'professionals' and to take what is offered without questioning whether alternatives are available. Hence, the normal and immediate response, when a research vessel is required, is that 'a naval architect should be engaged' and the responsibility for the task of 'designing' the vessel passed to him. Although this action must be taken, ultimately, it is a matter of timing and of degree. Only when the user staff have had ample opportunity of considering their needs for immediate programmes of research and for possible future work bearing in mind that the ship will not be completed in much less than five years and could take longer—and their needs collated into an agreed statement of the laboratory's requirements, is the project ready to be handed over to the consultant naval architect.

In addition to overseeing the Ernest Holt construction in 1947–48, preparatory work of this kind for the procurement of three vessels has fallen to the writer consecutively during the past twelve years. From this experience has developed the philosophy (Trout and Downham 1968, Trout 1974) that the responsibility of the user extends far beyond the simple preparation of a list of what is required to be built into the new vessel, to a major contribution to the planning and hence the fixing of a number of the primary design parameters of the vessel. This is not so pretentious a philosophy as may at first be thought.

The development of the design is a logical utilization of staff experience, such as is available within any fisheries laboratory. Specialist staff will, naturally, be responsible for stating their own research needs on board. No naval architect will be able to do that for them, and it is logical that research staff should ensure that these needs can be and will be met. All research equipment on board should be that which, from seagoing experience, is known to work at sea and to be reliable and easily used and maintained under the sea states and conditions to be encountered. Again, this must be the user's responsibility. Additionally, it is axiomatic that ship conditions must also be suitable for the equipment's unhindered operation, that is, the environment in which it is to work should be designed to be controlled within acceptable limits. Equipment must also be arranged most conveniently for the staff who are to operate it. This can be decided only on operational experience by the research staff. Thus to state the research requirements in total but alone is not enough, for they cannot be isolated from the ship design and equipment. The two must be considered as one composite entity, thereby forming a single concept to suit the users. It is up to the laboratory staff, therefore, to ensure that the design develops as they require, and only as they require, within the technology of shipbuilding and marine engineering (Trout 1974), but they should be aware of the problems of shipbuilding, too.

What, then, are the essential first stages and where are the major stumbling blocks to what, after all, would seem to be a straightforward piece of development design? Much excellent research work has been carried out at sea on commercial fishing vessels (Bennett and Eddie 1968), and since 1946 the Lowestoft laboratory has made and continues to make frequent use of commercial craft when suitable for certain biological programmes. Why not take a commercial trawler hull, design and redeploy its fish-handling/factory/hold spaces to provide laboratories, research facilities and accommodation for the scientific staff, and hence save the design costs? This is a constantly recurring query, raised by administrators and some scientific staff. The assumptions behind this question are:

(i) that the spaces available would be suitable in all respects, spatially and including the Department of Trade's rules on accommodation, for the required research facilities and accommodation;

(ii) that the vertical weight distribution of research equipment, many tons of which are so often carried above the main deck, would not adversely affect the stability of a vessel designed to carry (but which will not be carrying), say, 600/700 tons of fish in her hold(s);

(iii) that no further design work is required;

(iv) that the commercial design was good; some are not (Doust 1963). For example, one commercial fishing vessel design known to the writer required 200 tons of permanent ballast to be installed before trials could be completed! Three vessels were built to that unhappy design.

All of these assumptions may be arguable, and some difficulties overcome, if a commercial vessel is available and waiting to be converted. Undoubtedly, a conversion is better than no research vessel at all. If no such hull is ready for conversion, however, then the difference in design fees for a hull designed specifically to the requirements of the research proposed, compared with a commercial design adapted to those same needs—for displacement and stability calculations must still be made—would be of little significance. Some requirements could not be met at all, unless a major redesign and rebuilding of the engine installation, for example, were undertaken. One devised for commercial use and left unaltered would reduce even further the research effectiveness of the adopted design.

Furthermore, only those who have sailed in some converted wlers—admittedly side trawlers—and have been intimate- concerned with their conversion, know the limitations and xieties over stability and safety. There are also the disad- ntages of having to carry around the ocean quantities of llast in order to get the vessel to float like a ship, and look ss like a balloon on the water, and yet still be restricted to e weight of research equipment and the height at which it n be carried. Fortunately, many of the older conversions ould not pass the Classification Society Rules of today, and emories of their behaviour at sea underline the timely troduction of more rigorous stability and safety regulations f the Merchant Shipping Acts, i.e. "Board of Trade regula- ons" and other proposals (Holland-Martin 1969).

It is hoped that some experiences derived during the design f RV *Cirolana*, and described in the following sections, will emonstrate the role of the laboratory staff in co-ordinating quirements, design and construction. This duty is seen as) preceding the appointment of the firm of consultant naval rchitects and marine engineers; (ii) continuing through the ontract with the consultants to the completion of the tender pecification; and (iii) continuing during early discussion ith the shipyard as well as in all those meetings held during reparation of working drawings and construction, and final- y to builder's trials. This role is complementary to that of the onsultants and in no way duplicates their work.

Some laboratories may carry a large enough marine staff, omplete with drawing office personnel, to be able to produce reliminary drawings and with sufficient experience to act as upervising naval architects on both hull and machinery. Most laboratories, however, will have to arrange for one of he research staff to undertake the role of co-ordinator and hus to watch the interests of the seagoing research personnel. t must be realized that experience of research at sea, both on esearch and commercial vessels, is readily available amongst he staff of a marine laboratory. Thus the user staff has an ssential contribution to make to the design at all stages and t all levels and should be in no way daunted by the prospect. An interest in the principles of design is useful and also interest n ship design is obviously advantageous, possibly even essen- ial. The primary need, however, is for a desire to improve onditions for research and, indeed, all work at sea and to nsure, as far as practicable, that optimum design conditions re sought and met for each research field required on board, r that the best compromise is reached. Considering that the iologist's training has included traditionally, unwittingly erhaps, at least some of the basic principles of the relatively ew science of 'systems ergonomics' (Singleton *et al.* 1967, Trout 1974), he should feel at home in the field of marine ngineering and will learn quickly to reject those traditional pproaches and arbitrary decisions which threaten to provide nly second-best solutions to known needs, particularly if xperience at sea supports rejection. He must also, and with umility, realize that each line which he causes to be drawn n paper, has finally to be reproduced in steel, or an appropri- te material, and he must be sure, therefore, that each need is eal. This is the user's responsibility and, in particular, it ighlights the fact that some of the co-ordinator's major roblems are human ones.

One of the greatest of these latter problems likely to be encountered is the reluctance of staff to commit detailed requirements to paper until a very late stage has been reached in the design. This reaction is quite understandable, considering the frequency with which projects known to be costly must be delayed or pruned to suit the current financial climate, or even abandoned altogether after much time and thought has been expended on them. Experience, too, suggests that the alternative approach, a request for criticism of a tentative proposal circulated to all seagoing staff, is more likely to be fruitful and will save time in achieving the final statement of the laboratory's requirements.

Design procedure for a Fisheries Research Vessel

The approach to designing a fisheries research vessel must be largely a personal one, dependent upon the interests and experience of the staff available. It also depends upon the circumstances of the institution requiring the ship. The act of designing is a composite operation which takes place gradually in response to the stated needs. Although the resulting structure may well be complex, the stages by which the design evolves from the stated need to the final as-built vessel are, of themselves, simple and logical and should follow a straightforward sequence.

Several ways are open to the department or organization wishing to build, but it may be instructive to consider, first, the traditional way used by the fishing industry to build new tonnage. Normally no consultant naval architect was engaged but a shipyard was selected which had produced a successful vessel of, or similar to, the size and type which interested the owner. The naval architect at the shipyard produced a general arrangement and proposals for a ship and machinery specification, which were either accepted in their entirety or modified and finally agreed by the owner and his marine superintendent, who would normally have had long experience of the fishing industry's vessels as chief engineer or fishing skipper. Occasionally, brief proposals for a vessel were sent out to several shipyards with an invitation to tender. More usually no tendering occurred for commercial trawlers, the owners going directly to the yard of their choice.

Since the White Fish Authority was formed in 1956, their Grant and Loan Scheme has required that the fishing industry obtains not less than three tenders for each vessel above 35 tons gross, and the tenders must be based on a WFA approved specification. The WFA now provides the fishing industry with a vessel design service which also includes the all-important economic operational suitability (Doust 1964). This is available for the whole range of vessel sizes, types and fishing methods used around our coasts.

The traditional methods operated for many years and have had the result that design and construction of fishing vessels has remained in the hands of a relatively small number of specialist yards. It follows, therefore, that few independent consultant naval architects have had experience of trawler design and construction and the specialized machinery required for handling the catch at sea. Few of these trawler yards have experience of the special needs of research vessels, and this also applies to the consultant field. This raises, therefore, the problem of procedure for a government department wishing to build a large fisheries research vessel, and emphasizes the importance of the role to be played by the laboratory staff in formulating the concept of the vessel and drawing upon staff experience of research at sea.

SEQUENCE OF STAGES AND TIMING

The sequence of events which occurred during the development of the Lowestoft laboratory's vessel designs may be subdivided into seven main stages. Of these, the first three lie in the hands of the users and are critical to the success of the final vessel and should be accompanied by full and frank discussions at all levels:

Stage 1—Broad statement of policy, covering geographical areas, national and international commitments, and broad programmes of the types of research to be undertaken by the vessel.

Stage 2—Statement of scientific facilities required by tl several specialist user groups, plus their stipulations of oper tional needs related to their specific modes of working ar environmental needs for special equipment.

Stage 3—Collation of the scientific and ship requiremen into a 'whole ship concept', i.e. with a realistic description the vessel included—and this Statement of Requiremen circulated to the research staff for discussion and constructi criticism. During this stage priorities should be reappraise and amended as necessary, particularly with regard to inbui facilities or operational capabilities.

Once preliminary decisions have been taken on researc tasks, basic equipment content, operational needs, staff an crewing levels and other management matters, access to naval architect consultant is urgently needed so that furth refinement of the circulated concept may take place and b based on practical shipbuilding/engineering proposals. No mal administrative procedures, however, would probabl require the statement to be completed before any contract entered into with the consultants. Considerable time must b spent, therefore, by the staff formulating the design, on en quiries to manufacturers of several types of ship equipment o to specialist consultants (e.g. in the field of hull design, o noise suppression) so that the most realistic discussions ca be held with staff, and they can be appraised of what can, i all probability, be done or not done. This is time-consumin but probably less so (and therefore less costly) than goin straight to a consultancy contract before the staff have bee able to consider all needs and options.

Stage 4 is the transciption by the consultant of the State ment of Requirements into the hull, machinery and labora tory specifications and the accompanying general arrange ment drawings, for the tendering procedure; it is the consult ant's and the co-ordinator's major task. During this stag frequent discussions between co-ordinator and consultan are needed, so that the staff can be kept informed of th development of the design and are thus able to retain contro of any change to the overall concept of the vessel which migh result from compromises suggested.

For normal research establishments with minimal marin staffs, a comprehensive working contract with the consult ants is considered essential and will thus comprise three fur ther major stages, after that outlined in Stage 4. Once the specifications and general arrangement drawings have bee agreed and completed the consultants will undertake pre paration of the tender documents. In retrospect, however, a number of major changes could be made in the scope of the contract, to the advantage of the users in the writer's opinion these are outlined by Trout (1974) and discussed further in a later section of this paper.

Stage 5—HM Treasury procedures require a certain num ber of tenders to be sought according to a cost scale laid down for the procurement of research vessels or other similar large constructional contracts. Frequently, however, only a small number of firms may show interest, and the procedure adopted for the *Cirolana* contract was to advertise in the marine press, inviting those shipbuilders interested in tendering for a vessel of the type described to register their interest in writing to the Ministry. Only those firms which did so were issued with the tender documents. These included the Hull and Machinery Specifications, Laboratory Accommodation and Research Facilities, Preliminary Lines Plan, the Technical Schedule (for completion) and the form of contract which would operate between the Ministry and the successful tenderer. (The final agreed contract, which will include all alterations and additions, may be signed very late in the proceedings, frequently after the vessel has been launched.)

Stage 6—The analysis of tenders is carried out by the consultants and a short list of likely shipyards is prepared and the most suitable tender at the lowest reasonable cost put forward. Often many necessary adjustments are made to the breakdown of costs offered by shipyards, to ensure comparability of the tender costs on which the choice is finally made. This may not be the lowest tender. In fact, for trouble-free running of a complex research vessel it is almost axiomatic that the lowest tender should be scrutinized with the greatest solution before being considered at all seriously, and the yard visited to determine whether it possesses the required potential. A Technical Schedule (of subcontracted items) is usually asked for and takes the form of a list of components, together with the proposed manufacturer, power and type of each one, to be filled in by the shipyard. The suitability of each component can then be judged by the consultants against the operational needs of the vessel and the total power requirements checked. These latter are rarely stipulated in the specification and traditionally are left for the builder to propose.

Many factors are involved in the final choice of builders. Obviously experience in building research vessels is shared by few firms, but most firms which have already built stern trawlers would be suitable for consideration. In particular, knowledge of the main propulsion systems specified would also weight the choice, for example experience with diesel-electric installations.

Stage 7 is the construction of the vessel and here the consultant's duties include supervision of the entire building programme, costing and approval of amendments, and also attendance at all trials. During building one or more inspectors will attend at the shipyard each day or each week. Supervision also comprises a major component of the consultant's duties and takes the form of scrutiny for approval of all shipyard working drawings, several hundred of which will be produced and modified until each one can be agreed by the three parties. Approval of drawings will be carried out at the consultant's headquarters.

Because of the interrelationship between research requirements and the design of the vessel and its systems, the writer cannot emphasize too strongly the need for the users, also, to be totally involved throughout this phase and to scrutinize every single drawing, however unlikely it might appear that the structure or requirement depicted could influence the operation of research. Frequent visits to the shipyard are also essential.

The main stages may be summarized as a time scale as follows. Stages 1 to 3 cannot be expected to take much less than six months, with half that time required for the development of the most suitable dimensioned layouts of laboratories and associated work areas and research facilities, and an approximate layout for the rest of the whole vessel in block diagram form. Early access to consultants could reduce the length of the period considerably and benefit the whole operation. The time taken to write and agree Stage 4, the specification, must vary widely with the type of vessel but has been found to lie between six and fifteen months according to the sophistication of the vessel and her installations and the availability of any specialist consultants' proposals (e.g. relating to noise suppression) and the integration of those proposals into the rest of the design.

The tendering (Stage 5) is frequently subject to requests by the builders for time extensions because subcontractors' information is not available. In the case of *Cirolana* twelve weeks was allowed initially, and a three-week extension was asked for and given. During this period addenda to the specification are sent out to all firms tendering, as points raised by some firms are clarified or further information becomes available to the consultants.

Analysis of tenders (Stage 6) for *Cirolana* required eight weeks, whilst subsequent "clarification correspondence" with a short list of four builders extended by a further four weeks this period before a final choice could be made. The Letter of Intent, notifying the firm of builders that they had been selected to construct the vessel, was delayed for another four weeks whilst still further consideration was given to proposals put forward by the shipyard in their replies to questions in the Technical Schedule, and later by further correspondence, a total of about three months.

Offers of construction time (Stage 7) ranged between 80 weeks and 117 weeks at the time of tendering. In fact *Cirolana's* delivery time was 134 weeks, due to delays in delivery of major subcontracted components, an almost inevitable occurrence until subcontractors can be induced to accept penalty clauses or the shipyards can include them in all subcontracts.

Although theoretically each of the seven stages could be reduced in length, in practice major vessels appear to require about five years from the general agreement being given to proceed, to the final acceptance trials of the completed ship. Many modern research vessels have taken considerably longer and Ministry of Defence (Navy) vessels, such as prototypes of a class of warship, or auxiliary vessel, frequently take longer still, up to seven or ten years (Dymoke 1972).

Preparations for planning

A number of assumptions were made by the writer when considering the *Cirolana* project initially. These included the notion that during the early, exploratory stages:

(i) all sketches of laboratory and ship layouts prepared, on which the Statement of Requirements would be based, should at first accept no constraint on size which would limit any facility asked for in the vessel so that optimized arrangements should be developed before any compromise was attempted;

(ii) because major financial pressures on the vessel budget were attempting to limit length, an unorthodox fishing deck layout would result, which would differ from that of commercial vessels but which would be expected, nevertheless, to provide for the operation of a greater selection of fishing gears for sampling more and different species than would occur on a commercial British stern trawler;

(iii) the seagoing scientific staff alone should decide how research equipment and accommodation should be arranged, and that this aspect should include the appropriate environment in which the work was to be carried out, in particular, noise, vibration, and rolling must be controlled;

(iv) preparations for the future installation of equipment still under development should be made realistically, i.e. so that a minimum of shipwork and disruption of adjacent services would be necessary during their installation;

(v) the demand for AC power would probably increase with time, and hence the most economical method of ensuring 100 per cent standby alternator capacity should be sought;

(vi) because, on the whole, multi-aim cruises were likely to predominate, the relatively few staff to be carried would benefit from having (a) the fish-handling arrangements on the side deck instead of in the traditional below-deck fishroom area (b) a compact disposition of laboratories and working positions on one deck, as far as was practicable;

(vii) the wheelhouse should have 360° vision to give good visual cover of the after deck, and should also contain chart/radio facilities.

As the handling of fishing gear was to be an important part of the vessel's work a basic ingredient of the Statement of Requirements would be detailed proposals for the fishing system. The after trawl deck, its large winch, lifting gear and supporting gantries would obviously dictate, to a large degree, the whole layout of the after deck. As this deck also appeared the most suitable site for the laboratory complex, a commercial length of fishing deck would produce too long a vessel or displace the laboratories unduly far forward.

A review made in 1965 by the author of all available British and Continental stern trawlers then being currently described in the marine press or listed by the WFA (1964) provided the limits of deck length, which commercial vessels of between 195 feet (59.5 m) and 250 feet (76 m) overall had found viable. These lengths lay between 65 feet (19.8 m) and 120 feet (36.5 m), measured from the ramp top to the after side of the winch, and were used as starting points for alternative deck layouts.

Commercial trawl winch installations gave rise to considerable unease because of the tendency to increase the numbers of barrels and thus the overall length of winch to over 32 feet (10 m). Thus, in addition to the two main warp barrels and two for messenger/bridle combinations, a further barrel has been introduced to take the first heave with the becket around the trawl, whilst a sixth barrel was sometimes present to haul the cod-end up the ramp. In many cases whipping drums were omitted from the ends of the main winch shaft and replaced by strategically sited auxiliary winches to undertake a wide range of auxiliary trawl wire handling duties. Such small winches have the advantage of reducing the number and length of wires that must be strung about the deck if only a main winch is provided (Trout 1960). Objections to the 'split' main winch type of installation, used on *Corella* (Anon. 1967) following circulation of initial proposals for siting each half winch on the side decks, led to the necessity of considering only an orthodox main winch despite its space penalties and inflexibility.

Initially requests were made for eight relatively small single-purposes laboratories on the main deck, additional to provisions for a data-processing and a scientific plotting area. The total area asked for amounted to approximately 1,650 square feet (153 m^2) with appropriate storage facilities adjacent and a special 300 square foot (32 m^2) heavy hydrographic store for current meter buoys.

The desirability of reducing the number of individual laboratories was discussed on the expectation that relatively few would be in use simultaneously and that, probably, some sharing of space for compatible activities would be more economical of space and practicable, even during mixed-aim cruises. Finally, Wet Fish, Clean Biological, Dark Room Main (multi-purpose but largely for testing electronic equipment under development) and Hydrographic Sampling/Chemical Laboratories were retained, with the intention that they should all be grouped on the fishing deck. (Areas of laboratories finally provided were: Main Laboratory=505 square feet (47 m^2); Wet Fish/Quick Freezer Facility and Store=340 square feet (31.5 m^2); Hydrographic Sampling/Chemical Laboratory=325 square feet (30 m^2); Clean Biological=145 square feet (15.5 m^2), all on the main (fishing) deck; with the Plotting Room, Data Logger/Computer Centre on the fo'c'sle deck level, of 500 square feet (46.5 m^2). In addition the upper and lower Buoy Stores, forward on main and lower deck, were of 810 and 408 square feet (75.5 and 38 m^2) respectively. Thus total laboratory and storage areas were approximately 1,815 square feet (170 m^2) and 1,218 square feet (113 m^2) respectively, well above that originally requested.)

In developing the deck layouts, the optimal size and siting of each laboratory was considered highly desirable. A useful aid to achieving this aim was the simple approach of using no vessel outlines which might be regarded initially as placing artificial dimensional constraints upon planning, until all requirements had been included. Hence no limits were placed on length or beam, so that planning became a logical building up of optimally dimensioned units, in the correct spatial relationship. If an outline is used, planning runs the risk of deteriorating into a mere subdivision of that outline into labelled compartments, with little more than the area of each compartment used for guidance.

Five different deck and laboratory layouts were prepared on a simple block diagram basis, using the maximum and minimum fishing deck dimensions obtained from commercial designs which promised to be capable of handling the largest trawls, both bottom and midwater, which the vessel would be expected to operate.

Because of the wide variety of trawl-handling methods observed during the survey of commercial craft deck layouts, he fishing deck arrangements promised to raise few difficulties except for some inescapable cramping. However, before laboratories could be sited, even tentatively, the need to consider the content and layout of the engine room, in basic terms, became important so that realistic disposition of laboratories could be considered in relation to exhausts and funnels, the extent of the engine-room casing and its effect upon the rest of the accommodation.

At the time of the planning deliberations for this vessel (i.e. during 1965) the Ministry was building a smaller vessel, *Corella*, 137 feet (45 m) length overall (Anon. 1967). Her engine installation had been designed to reduce the amount of noise radiated underwater from the hull, by mounting the twin engines and gearbox on a heavy steel 'raft' (Plate 2), designed by W. H. Allen Sons and Company Limited, the engine manufacturers, and isolating the raft from the hull by means of standard commercial rubber mounts. In order to maintain the isolation of the engines, an intermediate cardan shaft was interposed between gearbox and propeller shaft and connected thereto by two rubber-faced couplings, thus avoiding a 'metal-to-metal' contact (Plate 3). Reduction of underwater noise had been found necessary, because levels produced by the orthodox trawler-yard type of diesel installation of *Clione* (Figure 1) (Anon. 1961) gave rise to considerable interference in electronic equipment and were limiting to the development of some apparatus. The 'Clione' operates primarily in the shallow waters of the Southern North Sea. *Internal noise and vibration were also unduly disturbing to personnel during long cruises. Unfortunately, delays in building *Corella* would not permit her trials to take place before the design for the new, larger vessel was due to go out to tender. However, a similar gearbox drive for the new vessel raised a number of space problems, particularly the overall height of such a rafted engine installation, and was not considered seriously.

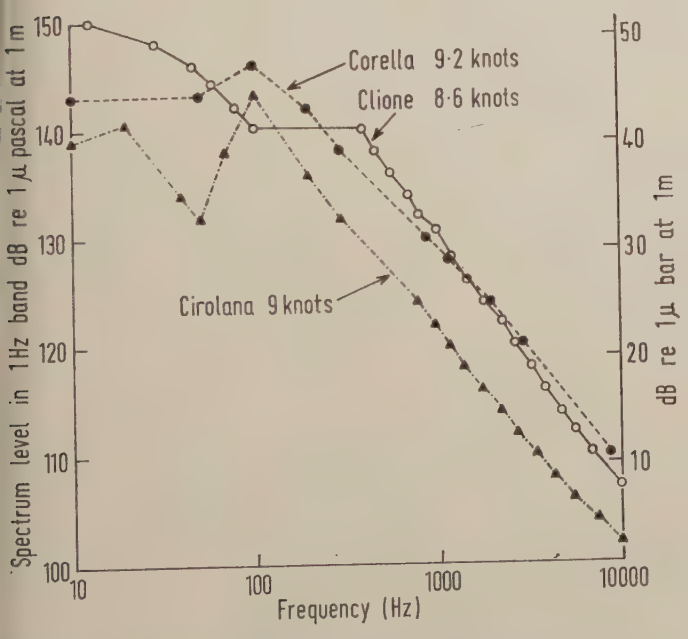


FIG. 1 R. Mitson's simplified underwater noise curve of RVS *Clione*, *Corella* and *Cirolana* (with acknowledgements to MOD(N) AUWE). (*Cirolana* curve of levels before treatment of propellers' trailing edge, etc.)

*Footnote *Interference probably due more to hull roughness of the* Clione's *rivetted construction, with overlapping plates, than to diesel engine alone plus cavitation arising from orthodox trawl propellor.*

Leiby (1961, 1968 and Buchanan and Bruce 1968) had utilized twin reciprocating 'Unaflow' steam 'motors' for *Atlantis II* to achieve low underwater noise, but discussions with steam plant manufacturers and research bodies indicated that the weight of boilers and the size and complexity of a steam installation would dictate, to a large degree, the whole layout of the vessel. Furthermore, a normal steam raising plant would not be suitable for the typical variability of powers required for the usual range of operating conditions and is also a source of noise over a wide range of frequencies. At the time of these enquiries the essential bridge control requirement could not be met with certainty unless turbo-electric machinery were used. Plant and installation costs would have been higher for the turbine machinery than for similar reciprocating steam, of course, and to these would have to be added an appreciably larger hull to house the duplicated steam raising plant necessary to provide for low-power running which typifies much research at sea. Bunker capacity of double that of a diesel machinery of comparable performance would also have been necessary. Despite the attraction of the well-known low maintenance of turbine machinery, compared with diesels of even medium speed, preliminary budgetary estimates of the alternative vessels indicated a significant saving of cost if a diesel-electric drive, and a smaller and therefore cheaper vessel, were adopted.

A diesel-electric installation had the added advantage of no mechanical connection between prime movers and the propeller, and hence was more readily noise-reduced by raft-mounting the generating plant. The large electric propulsion motor itself would produce little noise if a direct drive unit were used, i.e. with no gearing included. A further advantage of the system was the ability to provide a number of generator sets according to the range of power required in service. The most economical configuration emerging from all considerations, i.e. taking account of power levels required for the main operational modes, engine room length and ease of installation or access, for major engine breakdowns, was for three generators for propulsion placed in line across the vessel, and arranged to drive the main trawl winch and bow thrust motors and the main propulsion motors, in a constant current loop for control of powers.

Once the general concept of the engine installation had been crystallized, certain limitations of laboratory sitings were foreseen due to such structures as engine-room casing and funnels, but no attempt was made to locate them precisely and plan the laboratories around them. It was thought that they could be accommodated without undue difficulty and that sufficient flexibility remained in the layout options for siting laboratories and work spaces within the framework of the maximum and the minimum after deck lengths.

Each deck was considered in turn, initially from the point of view of research facilities, and later cabin accommodation was also included as generalized requirements, until flexible and convenient layouts had been established for all foreseeable conditions.

It was not found possible to provide all the facilities required with the shortest (65 feet: 21 m) after fishing deck. The limiting factor was not, however, laboratory space but that required for cabin accommodation to the then Board of Trade standards whilst providing an adequate engine-room casing. A near-optimum deck length of 85 feet (28 m) produced a vessel of around 255 feet overall length (83.5 m) which was thought to be too large. However, the development of the several layouts, rough though they were, had pinpointed the major space problems to be solved by the consultants and suggested where and how pruning of laboratory accommodation should occur.

Further discussions of the possibility of reducing size to try to meet a desirable, but arbitrary, length, and the additional constraints on space seen to be practicable, permitted development to be controlled until, finally, the smallest workable vessel design resulted. The layout still offered the research facilities required in such a way that the maximum, realistic number of research programmes could be mounted during a given cruise, without unduly reducing the effectiveness of any. Thus, it was anticipated that multi-aim cruises would predominate but certain combinations of activities only were provided for and thus a minimum number of laboratories resulted. Further reductions in the number of laboratories promised to limit the scope of probable combinations of research programmes, whilst still further limitation of length, always an early constraint imposed by financial reasoning, promised to curtail some activities and reduce the potential speed of the vessel and her ability to handle the larger mid-water nets.

A brief description of the proposals for the vessel, which is based upon a 'total concept' derived from the layouts developed and from which the 15,000 word Statement of Requirements was drawn, appears below.

The statement of requirements for *Cirolana*

GENERAL DESCRIPTION

The vessel was required to operate midwater and bottom trawl gears over a stern ramp in both Arctic and southern Atlantic waters, i.e. she must be capable of passing through the tropics at all seasons. She would undertake all basic fisheries and fisheries hydrographic research programmes. She would require a maximum endurance of 9,000–10,000 nautical miles for the long cruises anticipated, viz. to the South Atlantic fishing grounds, as well as to the more normal areas such as the Barents Sea, the Grand Banks and Greenland. Extensive laboratory and comfortable living accommodation was called for, with generously rated heating and air conditioning systems for the extremes of climate expected to be encountered. A passive roll stabilizing tank was also considered essential to extend the operation of laboratory techniques into higher wind and sea states.

Scientific staff levels were agreed to be small by some countries' standards and 10/14 scientists were to be accommodated, including the occasional carrying of up to four students. As it was considered desirable that day accommodation (messes, galley and recreation spaces) should be on the same deck as the main working areas, and that the laboratories should open on to the fishing deck, sleeping cabins for both scientists and crew were to be on the lower deck, to port and starboard respectively. Centre line bath, toilet, laundry and storage facilities for linen, etc. were to be available from two fore and aft alleyways port and starboard, which would give access to the cabins at the ship's side (Figs. 2, 3 & 4).

Only senior ship's officers' and the senior scientist's cabins were to be in a superstructure at boat-deck level, which would also house the central scientific plotting room and future data logger/computer complex, so that easy communication with the bridge and between scientists and ship's officers would be possible at all times. Great emphasis was placed on the need for simple and convenient access companionways for all personnel between their relaxation and working areas. Additional access routes were to ensure that crew members did not have to pass through laboratories or along alleyways between them.

All accommodation was to be planned as nearly as possible in the 'middle half' of the hull, to avoid the discomfort of living or sleeping in the region of the bow, where accelerations and forces due to slamming in head seas are high. This rule was to apply to scientific staff and crew alike. The 'ends' of the vessel were to be kept for fishing gear storage (aft), and longline and buoy stores (forward).

Crewing was to follow a three-watch system, both on deck and in the engine room, but for fishing operations two watches would be on deck, i.e. the normal watch and the standby watch, as on commercial fishing vessels. Each deck watch was to be composed of a Fishing Officer (the Mate, Bosun or Third Hand) and three Deckhands. Thus, eight men would be on deck at any one time, with the non-watchkeeping Fishing Skipper in the wheelhouse. When fishing was required to be continuous, i.e. throughout the 24 hours, then the Mate would take over in the usual way and leave seven men on deck, only just adequate for handling the gear in reasonable weather. For this reason and also because of the increased maintenance required by a vessel larger than the 193 foot (59 m) Ernest Holt, which also carried nine Deckhands, their cabins were to be large enough to take an additional man per watch without crowding if this should be found to be necessary later. However, normal non-fishing research activities could be undertaken by one watch alone, e.g. on oceanographic stations and during towed plankton net surveys.

The engine room, apart from a sophisticated noise reduction treatment to meet stringent underwater noise target levels, was to be straightforward and 'watched', from a machinery control room, because of the wide variations of operating conditions foreseen. It was to be staffed by a watchkeeping Engineer and Greaser, with the Chief Engineer and an Electrical Engineer available at all times, i.e. as non-watchkeepers. A Deck Engineer for winch/crane maintenance was also to be carried on a 'dayman' basis.

A catering/cleaning staff of six was thought to be adequate, provided that labour-saving cleaning equipment and well planned galley facilities were available.

For communications a Wireless Officer would be required, whilst on some cruises, such as multi-ship international cruises, provision for a second Wireless Officer was considered essential to give 24 hour communication coverage. The cabin for this additional officer would be treated normally as a spare cabin for a visitor or additional scientist.

Captain and Chief Officer would, of course, be non-watchkeeping but also available at all times, and thus the maximum officer/crew complement was to be 31 initially, with the possibility of its being increased to 34 if experience of running the vessel showed the increase in deckhands to be necessary.

Laboratory accommodation was to be grouped on both sides and forward of the fishing deck and was to comprise:

(a) Wet Fish Laboratory, to open from the fish pounds, which were to be on the port side deck, instead of the more usual lower deck used on most commercial stern trawlers of comparable size;

(b) Clean Biological/Physiological Laboratory;

(c) Dark Room;

(d) Main Electronics/Hydrographic Electronics complex; the two laboratories to be contiguous but separable by folding partitions and associated with the enclosed starboard hydrowinch working position/sampling laboratory and workshop;

(e) separate Hydrochemical Laboratory plus storage for samples and bottles;

(f) spare laboratory or store of small size, as far aft as possible;

(g) a data handling room was required for future data logger/computer facility, for sonar/echo surveys with scientific plotting and charting areas within easy reach of the bridge;

(h) weather station on the bridge.

Initially a fish tank room was projected at the forward end of the fishing gear store, but space considerations of a facility so infrequently used caused this to be deleted. As the engine room was to be as far aft as was practicable but its dimensions were unknown, no attempt was made to produce layouts for the laboratories at this stage. Their dimensions and precise siting would be influenced by the positions occupied by silencers and funnel casings. These, in turn, would be dependent upon the type of main and auxiliary engines advocated by the consultants, discussions with whom had to await their formal appointment. Hence tentative minimum dimensions were included in the Statement, which also indicated that considerable flexibility was possible, apart from obviously essential relationships. As soon as an engine-room layout became available, a fully detailed laboratory layout would follow

with its own equipment specification. This Laboratory Specification was to be included with the Hull and Machinery Specifications as part of the tender documentation.

Certain special facilities were included in general terms only, viz:

(a) a monorail system for transport of heavy gear along alleyways and deck to major laboratories;

(b) a screened cubicle for electronics test gear;

(c) screened cabling throughout the laboratory area to reduce electrical interference to desirable limits, which were stated;

(d) laboratory electrical supply, i.e. for all research equipment, sounders, etc. and navigation equipment, to be from a stabilized voltage/frequency source;

(e) a 'chains' platform to extend outboard from the hydrowinch working position;

(f) a circular 'well', approximately 2 feet 4 inches (0.70 m) diameter to run from upper-boat-deck level to the flat plate keel. A further 'well' to be in the Hydro-electronics Laboratory for a wide range of equipment requiring to operate on 'stalks' clear of the hull boundary layer turbulence;

(g) a bulbous bow viewing chamber might be desirable at a later stage in research;

(h) a folding after deck, self-supporting, to bridge the ramp whilst handling certain equipment over the stern.

A major requirement was for a davit/pallet system for loading and offloading scientific and engine-room stores and for provisioning ship, because the vessel's high freeboard would preclude the use of manpower alone for lifting heavy scientific equipment, apparatus and stores from quay to ship. Provision for a hydraulically-operated 'boom swinger' on the after goal-post mast and for the starboard workboat davit to be so used, with unloading areas related to the monorail included in (a) above, was considered essential.

A proposal to install fixed live-fish tanks and a built-in underwater tagged-fish release chute was finally abandoned as being too infrequently required to justify the space and expense of the installation. So too was a quick-freezer blast tunnel and cold store for small (15 ton) samples of fish from new fishing areas of potential interest to commercial trawler owners. Until a specific demand was apparent, this installation was thought to be another uneconomic use of space and was to be left void for possible future development.

The remainder of the accommodation spaces, the three messes and recreation rooms, were to be grouped around a fully-equipped and well-planned galley which would supply each mess in the most convenient manner for the relatively small catering staff. Layouts of the messes/recreation rooms were to allow the use of 16 mm cine projectors during long passages and also to give a feeling of space and comfort with indestructibility of materials.

In view of the importance placed upon precise manoeuvring on station, it was considered necessary that the ship's windage profile should be planned to help the vessel maintain station head to wind and sea with the use of minimum power, and thus the overall dimensions of any superstructure should be kept within reasonable limits. This would also be helped by the positioning of the engine room, and therefore funnels, aft. Thus a bridge which gave a full 360° view, i.e. of the after fishing and working deck as well as forward, would need to be, preferably, aft of amidships and so tend to maintain the station heading without the application of undue correcting forces by rudder and/or bow propeller. The bridge, which w required to house navigation and charting facilities, rad room and weather station, was to be able to undertake ship movements without reference to the engine room. particular, the starboard bridge wing was to be sited so th the Officer of the Watch would be in the optimal position observe and correct the tendency of the hydrowire or oth gear operated overside to stray from the vertical.

Full bridge control of all ship's movement was, therefor a basic requirement, and thus direct control of the power t main and auxiliary propulsion systems was to be provided t the Officer of the Watch under (normally) all operationa conditions by means of appropriate consoles. This mean that consoles should be grouped for passage making, fishin and station operations. Three basic work modes of (i) o passage, (ii) fishing and (iii) on station suggested that thre levels of power and three propulsion generators would b required. Each of these sets was to be resiliently mounted on common raft, and the raft itself also isolated from the hull, t achieve an adequate reduction of machinery noise to mee underwater noise levels over the specified range of frequenc ies. The sub-raft supporting structure was to be heavy and it construction to be such that it could be considered 'infinitely rigid', so as to minimize resonance of hull or tank panels.

Other constructional requirements included a smooth underwater hull to provide good flow characteristics and sufficiently strong to combat the later development of flow noise from the corrugations in the plating usually character- istic of normal welded construction.

In certain main deck laboratories the camber was to be reduced or eliminated to simplify the temporary bolting down of laboratory equipment on to modular fixings, and the instal- lation of the screened cubicle which was to be a standard shore (i.e. non-marine) laboratory installation.

Many other detailed requirements, which need not be reproduced here, were also included in the Statement of Re- quirements, but no matter how fully detailed such a compila- tion is, much work has to be undertaken by the consultant naval architect and marine engineer to clarify and expand the Statement into a Hull and a Machinery Specification suitable for tendering purposes.

It will be seen, furthermore, that specialist consultants in the fields of noise suppression, anti-roll tank design and hull form of a trawler-type vessel must also be involved at the earliest opportunity, so that the whole design may be devel- oped and co-ordinated throughout by the main consultant.

Only in this way can delays due to late arrival of informa- tion on major items, causing changes in layout or basic equipment, be avoided in the design process. Sufficient num- bers of changes of mind, or late decisions to include additional items, will occur inevitably or be forced upon the designer that it becomes important to make provision for such changes in the accounting side of this project. A figure of 2 per cent of the contract cost of *Cirolana* was included in her estimated total cost, to cover the costs of alterations and additions ex- pected during building. This figure was adhered to, although some cuts in desirable but non-essential facilities had to be made to achieve this goal.

ssessment of ome special measures n *Cirolana's* design

he Statement of Requirements called for solutions to a num-r of operational, environmental and constructional needs mmon to most modern fisheries research vessels. Whilst ividually not novel or difficult, when combined in the rela-ely small compass they appear to give a certain degree of mplexity. Seen, however, in comparison with the several tirely new types of cargo-carrying vessel, introduced by the ipbuilding industry within the past decade or so (for ex-mple, the palletized cargo vessel, roll on/roll off and con-iner ships, barge carriers, with between 40 and 50 barges ch holding up to 300-,1000 tons of cargo, natural gas nkers designed to carry liquid hydrocarbon gases at atmos-heric pressure, but at —164°C in non-corrosive tanks of ew design) the fisheries research vessel's problems are only inor matters of engineering and constructional detail within design framework. They are readily achievable if careful ttention to that detail is maintained throughout design and uilding, but are novel to the small shipyards, normally uilding trawlers, tugs or dredgers, that would be expected to e interested in tendering for a ship which is essentially eveloped from a fishing vessel.

Although many types of research are carried out at sea the isheries research vessel has only three modes of operation. hese are (a) free running at any selected speed, (b) fishing, nd (c) stopped on station. The special measures taken to nsure maximum effectiveness of research undertaken by *Cirolana* in these three modes have already been described Trout and Downham 1968) and included the following:

(a) limitation of underwater noise and of vibration and noise within the vessel;

(b) a device for manoeuvring and maintenance of heading on station;

(c) bridge with maximum vision and all ship controls;

(d) passive anti-roll tank;

(e) improvements in fishing gear handling;

(f) construction.

The following comments are offered after *Cirolana* has been in operation for four years.

(a) UNDERWATER NOISE LIMITATION

This need arose from the development of acoustic techniques for estimating fish stock abundance (Cushing 1952, 1964, Gerhardsen *et al.* 1968). A design study contract was undertaken for the Lowestoft laboratory by a section of Yarrow and Company Limited, their Yarrow–Admiralty Research Department, Glasgow, prior to the appointment of the Ministry's main consultants, who were currently overseeing the building of the research vesel *Corella*. Early discussions with Y-ARD had indicated that the study would take several months and that the results would dictate much of the structure and layout of the engine room. It would also affect the construction of the hull. Because many major decisions had to await the appointment of the Ministry's consultants, assumptions had to be made concerning the probable power and number of diesel generator sets and the manufacturer and the type of diesels to be installed. The assumptions were close enough to the final decisions not to affect the proposals.

In order to try to meet the stringent noise target levels, based upon the earlier ranging by the Ministry of Defence (Navy) Underwater Weapons Establishment (Figure 1) of the untreated RV *Clione*, three aspects of design had been considered:

1 Hull flow noise was expected to be minimal, following the use of the National Physical Laboratory's optimized hull design technique developed for stern trawlers and used to produce the hull design of RV *Corella* (Trout 1974). Y-ARD also proposed improved designs of hull openings, to avoid cavitation, which otherwise could generate noise at the higher frequencies. A fair and smooth hull was also considered essential, and elimination of the normal frame corrugations was to be achieved by increasing plating thickness to 0.75 inch (19 mm). Furthermore, surplus weld material was to be ground off below the waterline. No bilge keels were to be fitted; their function was to be taken over by the passive anti-roll stabilizer tank installation.

Absence of the frequently fitted lateral thrust tunnel, its place being taken by a retractable, rotatable bow propeller, also permitted a clean hull flow in the critical region of the bow (Trout and Downham 1968) (Figure 2).

2 The double resilient mounting of main and most auxiliary machinery was designed to minimize the transfer of low frequency, high energy, noise and vibration via the hull structure to the sea. Special care was taken by the manufacturers of the main diesels (W. H. Allen Sons and Company Limited) to limit out of balance forces, and hence vibration, by minimizing weight differences between moving parts in adjacent cylinders (Table 1) to small but practicable values.

Each diesel generator/alternator's heavy steel bed-plate is resiliently mounted on a box-shaped raft, weighing some 80 tons (Plate 4); the raft is isolated from the supporting hull structure, the double bottom tank top, by a standard pneumatic mounting system (Anon. 1968) which can be operated when required. The total weight of the machinery installation and raft is approximately 260 tons. Figure 6 shows the general principle adopted. When not operating, the mounting system still maintains a degree of isolation between raft and hull in the form of a synthetic 'rubber' pad on which each mount rests, even when the raft is wedged in the 'down' position during bad weather (a Lloyd's requirement) and although the wedges act as transmission paths-minor degree only.

TABLE 1 *Variation in weights of moving parts of piston assemblies; engines type 6 PBC-S37E*

Set	Cylinder number	Piston Assembly weight lb oz	kg
A	1	415 4	188.523
	2	415 7	188.578
	3	415 8	188.637
	4	415 9	188.665
	5	415 10	188.694
	6	415 15	188.325
B	1	415 1	188.438
	2	415 1	188.438
	3	415 2	188.467
	4	415 3	188.495
	5	415 4	188.523
	6	415 4	188.523
C	1	414 13	188.325
	2	414 14	188.353
	3	415 0	188.410
	4	415 0	188.410
	5	415 0	188.410
	6	415 1	188.438

3 Y-ARD advised that the entire main machinery installation, plus as many of the auxiliaries as was practicable, should be covered by a single hood mounted on the raft (Figures 5 and 6) in order to prevent airborne noise of the higher frequencies from reaching the hull structure and so being passed on into the sea. To provide easy access for maintenance a single hood was preferred to individual hoods for each noise producer. These had been found to hamper maintenance unduly in RV *Clione's* engine room and were abandoned. (As a result of a desk study carried out by the consultants and the diesel engine manufacturers for emergency conditions, the hood dimensions and engine spacings proved entirely satisfactory during the major task of dismantling a main diesel and replacing the crankshaft damaged in an explosion resulting from a blockage of the main bearing lubrication system.)

The desirability of fitting a specially designed multi-bladed propeller, i.e. with more than the normal four blades, was discussed. The desire was to delay the inception of cavitation and hence to achieve the highest possible acoustic surveying speeds. Advice derived from these discussions, however, was that the propeller speed with the powers proposed should not produce serious cavitation.

Other noise suppression measures provided included lining the engine room and propulsion motor room and all accommodation deckheads with absorptive material; lining of fan ducting to accommodation and to the engine room with similar material; mounting engine exhaust and silencer systems resiliently; lining the 'run' of the hull in the region of the main thrust bearings with concrete, carefully and specially bonded to the hull, to minimize hull 'panel' resonance; mounting the hydraulic steering gear on 'Tico' pads to limit transmission of noise of the hydraulic drive to the hull; supporting all pipework to and from noise producers in rubber-lined hangers; providing all main and auxiliary machinery fuel, cooling water and lubricating oil systems with flexible pipe inserts both on the raft and to and from the raft.

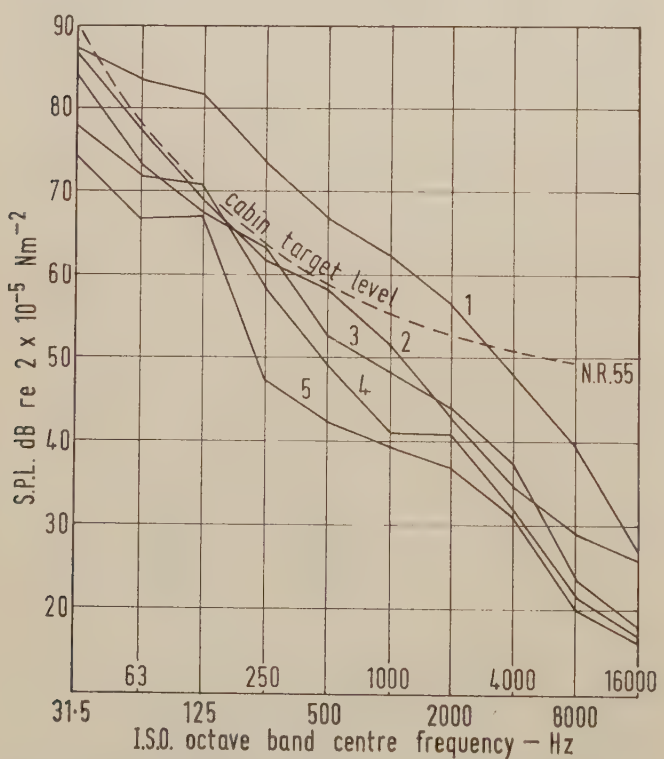


FIG. 7 Noise levels within *Cirolana's* lower deck cabin accommodation (published by kind permission of M. Hartnell-Beavis).

1 Adjacent to steering gear flat (student's cabin).
2 Deck above engine room aft end (second engineer's cabin).
3 Deck above engine room forward end (after scientist's cabin).
4 Forward 3-men cabin (ventilation on).
5 Forward 3-men cabin (ventilation off).

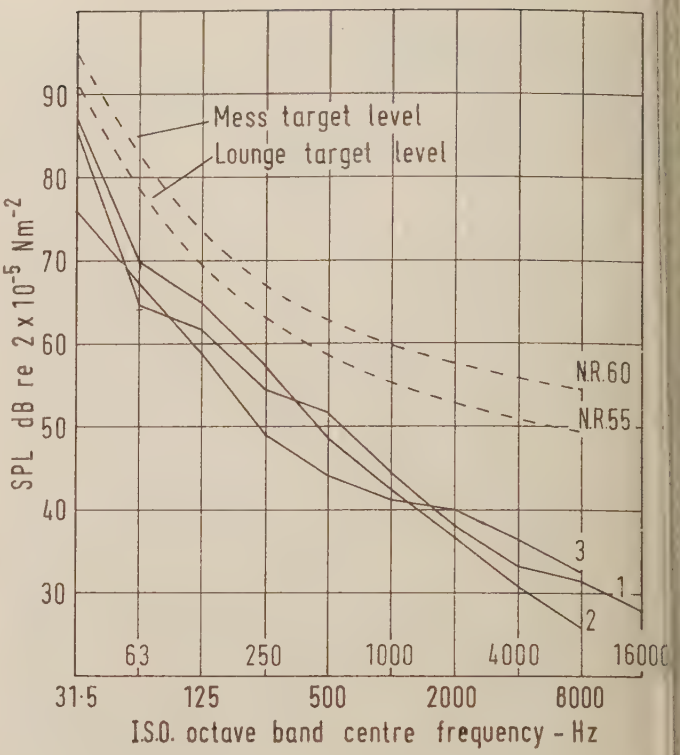


FIG. 8 Noise levels within *Cirolana's* mess and recreational areas.

1 Captain and scientists' mess (upper deck).
2 Captain and scientists' recreational room (upper deck).
3 Crew's mess (upper deck).

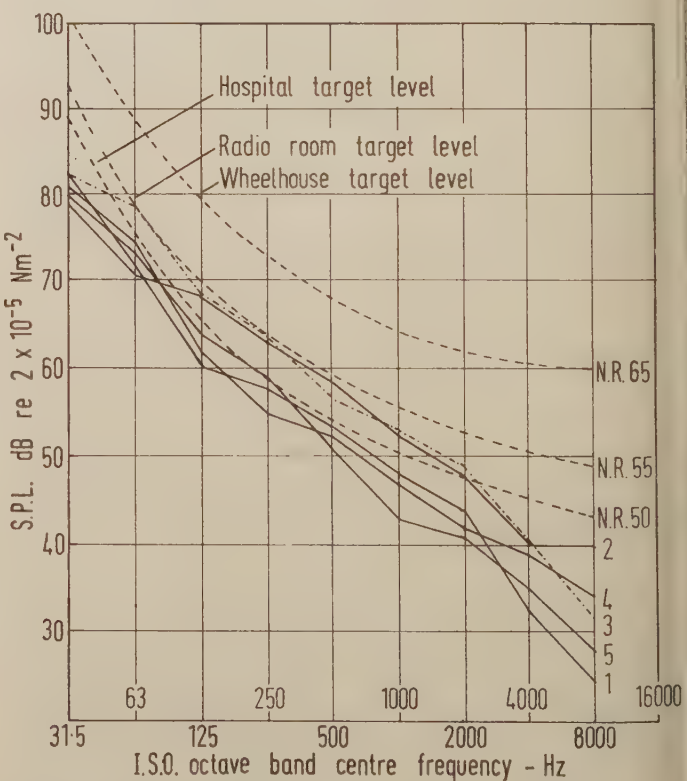


FIG. 9 Noise levels within *Cirolana's* wheelhouse, laboratories, radio room and hospital.

1 Hospital (boat deck).
2 Wet fish laboratory (upper deck).
3 Main laboratory.
4 Wheelhouse (centre).
5 Radio room (bridge deck).

Most of the initial disappointments with the results of the ise reduction measures have been overcome with more ention to detail. It is hoped that eventually the two sources noise which remain can be eliminated. These are from the draulic steering gear, which causes annoyance to personnel the after accommodation (Figures 7, 8 and 9) (Hartnell-avis 1973), and a considerable reverberant build-up of air-rne noise which occurs between the underside of the raft d the double bottom tank top. This space will ultimately be ated with absorbent material, thus improving the low fre-ency underwater noise spectrum by between 5 and 10 dB.

Figure 1 shows RV *Cirolana's* underwater noise curves, in mplified form, compared with the data for the untreated V *Clione* and for the simple rafted installation of the smaller V *Corella* (derived from Ministry of Defence (Navy) Under-ater Weapons Establishment range data). Underwater oise and vibration and the measures required to analyse and ombat them are complex fields (see Vatz and Williams 1962, ijak 1972) and only general comments are appropriate in this aper. Figure 1 shows a major peak in *Cirolana's* curve at pproximately 100 kHz, due to a 'singing' propeller. The ropeller's trailing edge has been treated and the singing liminated, but the vessel has not yet been re-ranged (May 974).

Figure 10 demonstrates the improvements achieved by ttention to detail. Self-noise was measured during four ruises at the terminals of a hull-mounted 30 kHz transducer curve 1) before a recently-fitted additional main engine ooling water intake grill has been correctly fitted. A ¾ inch (19 mm) deep depression around the grill was flushed off to the same extent as all other installations of similar original grills. Cavitation due to the depression and pitting of the hull plating ceased and the noise was reduced (curve 2): curve 3 resulted from small propeller damage being corrected. Curve 4 and a deep-water survey speed of 10+ knots was achieved after the light steel plate covers to the Kort Rudder crown bolts were replaced by wooden plugs and their propeller-induced resonance eliminated.

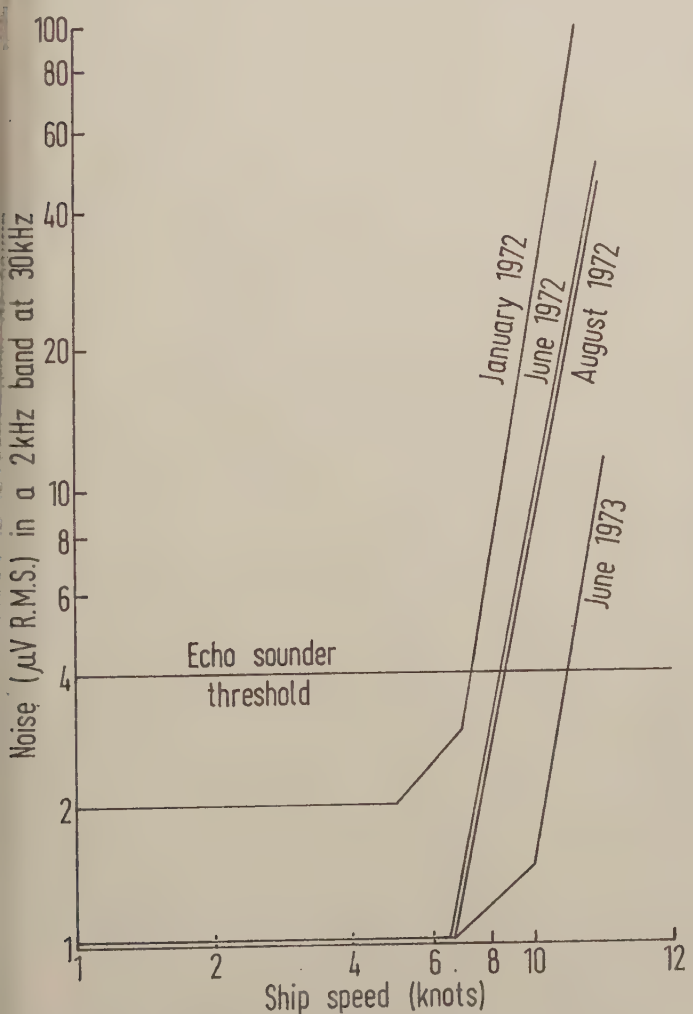


FIG 10. Self-noise levels at the terminals of *Cirolana's* 30 kHz hull-mounted transducer after propeller treatment and attention to streamlining detail (see text, page 11).

When the vessel is under way at 12 knots and power is switched from the propulsion motors, self-noise drops immediately (Mitson, pers. comm.), suggesting that propeller cavitation is responsible for the bulk of the remaining underwater noise affecting the 30 kHz (and similarly the 100 kHz) survey transducers. No further improvement can be expected until an improved design of propeller, such as was called for in the specification, can be fitted. This, and the other noise improvements referred to above, should ultimately allow a 12 knot survey speed to be achieved.

Apart from the noise experienced by personnel in the after cabins the vessel generally has a low noise level in all accommodation, with only the ventilation/air heating system noticeable at each outlet (Figures 7, 8 and 9). The starting and stopping of the main engine room air compressor, port side (Figure 5), is noticeable in all below deck cabins and in the saloon as a gentle tremor. That of the air conditioning unit, starboard side, is noisy by contrast with the low background noise of the vessel and if extensive research is required in the warm-water areas, e.g. south Atlantic, then special rafting/hooding treatment will be required to bring internal and underwater noise levels to acceptable limits.

A second bonus, i.e. additional to the general low noise in accommodation areas, has accrued from those measures taken to limit underwater noise and vibration. Optical microscopes are used routinely in the clean biological laboratory (Figure 3), bolted firmly to the fore and aft bench and used at powers up to x1000 magnification, i.e. with a 1/12 inch (2 mm) oil immersion objective lens. These powers are used to identify μ-flagellates and are quite practicable in winds of up to Beaufort force 5–6 (Reynolds in prep.).

(b) A DEVICE FOR MANOEUVRING AND MAINTAINING HEADING ON STATION

A foreseen benefit of the retractable, rotatable bow propeller design (Figure 2) (Trout and Downham 1968) over the conventional lateral thrust tunnel units was that it could be housed within the hull, leaving the latter flush. It would thus induce a minimum of turbulence and hence flow noise, provided that careful matching of the hull plating and the edges of the retractable propeller 'pod' could be achieved. No loss of ship speed follows the fitting of this type of thruster, in contrast to the lateral tunnel (English 1963).

The builders, Ferguson Brothers, were able to fair the pod smoothly into the lines of the hull immediately aft of the small bulbous bow (Figs 11 & 12) and to limit the gap between it and the surrounding hull plating, when the pod is fully retracted, to approximately 7–8 mm. A minimum of flow noise results from this excellent fit and contrasts with the situation arising from alternative manoeuvring devices, viz. the 5 foot (1.52 m) diameter openings of lateral thrust units (English 1963), or the tandem openings on the centre line of the keel required for the water jet type of installation (Buchanan and Bruce 1968, Anon. 1974). This latter device has the additional acoustic hazard of a set of intake and discharge vanes in the keel plate and in line with the hull-mounted sonar/sounder transducers. No simple means of closing the openings for survey conditions appear to be available for either of these devices.

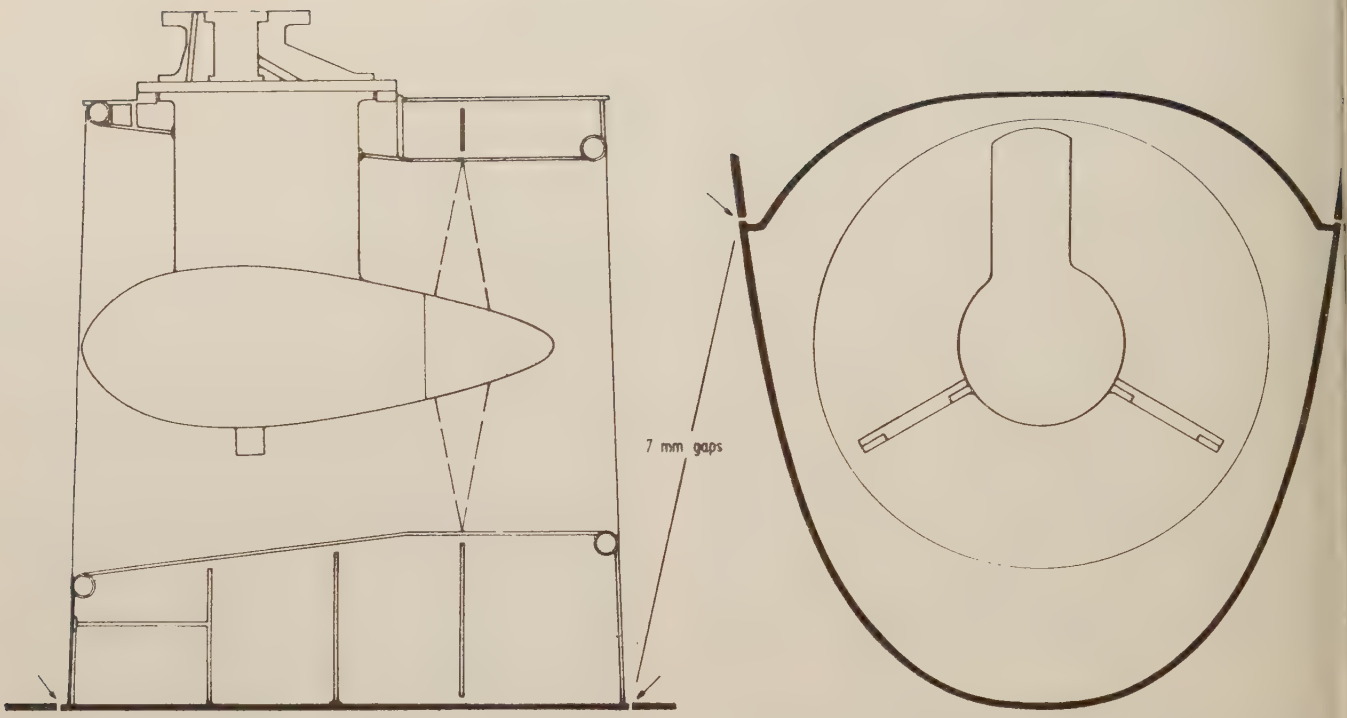


FIG 12. *Cirolana's* retractable and rotatable bow propeller and pod. Shown rotated, i.e. with propeller forward, and retracted.

On the unit fitted to *Cirolana*, the combined Kort nozzle/hull fairing forming the pod which shrouds the propeller is, of course, wider at the entry annulus (Figure 12) and tapers towards the thrust or exit annulus. By arranging for the pod to rotate when the unit is to be housed, i.e. with the propeller forward, it was possible to fit the whole mechanism further forward and into the narrowest part of the waterlines aft of the swelling of the bulbous bow. It is thus sited further forward and in less valuable space than could be utilized by either of the other alternative devices referred to, as can be seen by a comparison of the relative position of *Scotia's* installation (Anon. 1971a) with that of *Cirolana*. In operation this position confers an improved directional stability to the vessel, as if she were under tow.

Static thrust is 5.5 tons, approximately, at a maximum of 1,200 rev/min from a 350 hp (261 kW) DC motor in the constant current loop system. The control of propeller speed is from 500 to 1,200 rev/min: speeds below 500 rev/min would provide insignificant thrust. Rotation of direction of thrust through 360° takes place in less than 2 minutes, so that any heading may be achieved with use of bow propeller and main propeller and rudder, according to need on station. If necessary, the unit can be used to drive the vessel at up to 6 knots in light or moderate weather, e.g. under emergency conditions such as main propulsion machinery failure or main propeller damage or loss.

The disadvantages of the mechanism are apparent. It cannot be used in shallow harbours because of the extension of the pod to 7.75 feet (2.4 m) below the keel, but its deep immersion becomes a positive advantage when it is in use in the open sea, the primary purpose for fitting it, because heavy weather can reduce the effectiveness of a lateral thrust tunnel, which begins to break surface and lose thrust at a relatively low Beaufort wind force (Trout and Downham 1968). Because of its forward position the pod and 'stalk' of such a device must be very robustly built to withstand the high impact loads of 'slamming' under head sea conditions, both when operating and when in the housed position.

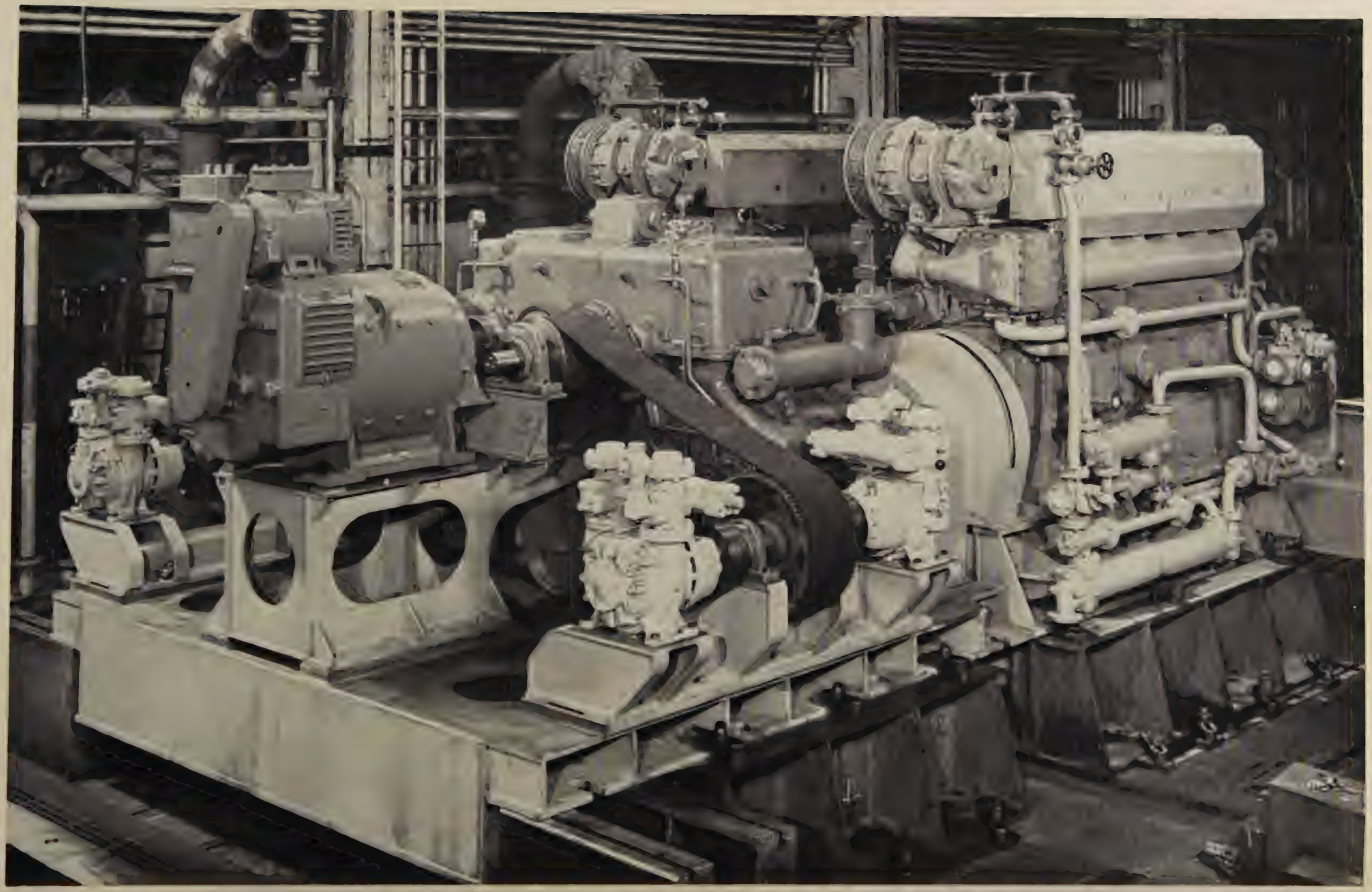
Secondly, due to the high speed of the propeller, the unit is naturally noisy on station, particularly with the vessel directly head to wind and sea. If, however, manoeuvring to a particular heading is attempted by the combination of Kort Rudder and main and bow propellers, the effect on the operation of, say, a 'precision depth recorder' by turbulence from the bow, can be minimized. Some Officers of the Watch appear to be better than others at anticipating the bow thrust and main rudder angles necessary to maintain position relative to a buoy mooring or a vertical cast, and practice is required before this skill in seamanship is fully developed. Care and good seamanship must be exercised when about to pick up a moored buoy station, to avoid lines fouling the extended pod.

All controls (i.e. extension, rotation, speed and housing of the unit) are located at each bridge-wing console (Figure 13). A local control station, for buoy-recovery, is available on the fore deck, at the starboard baggage davit, a wandering lead permitting the operator to stand overside on the leadsman's platform.

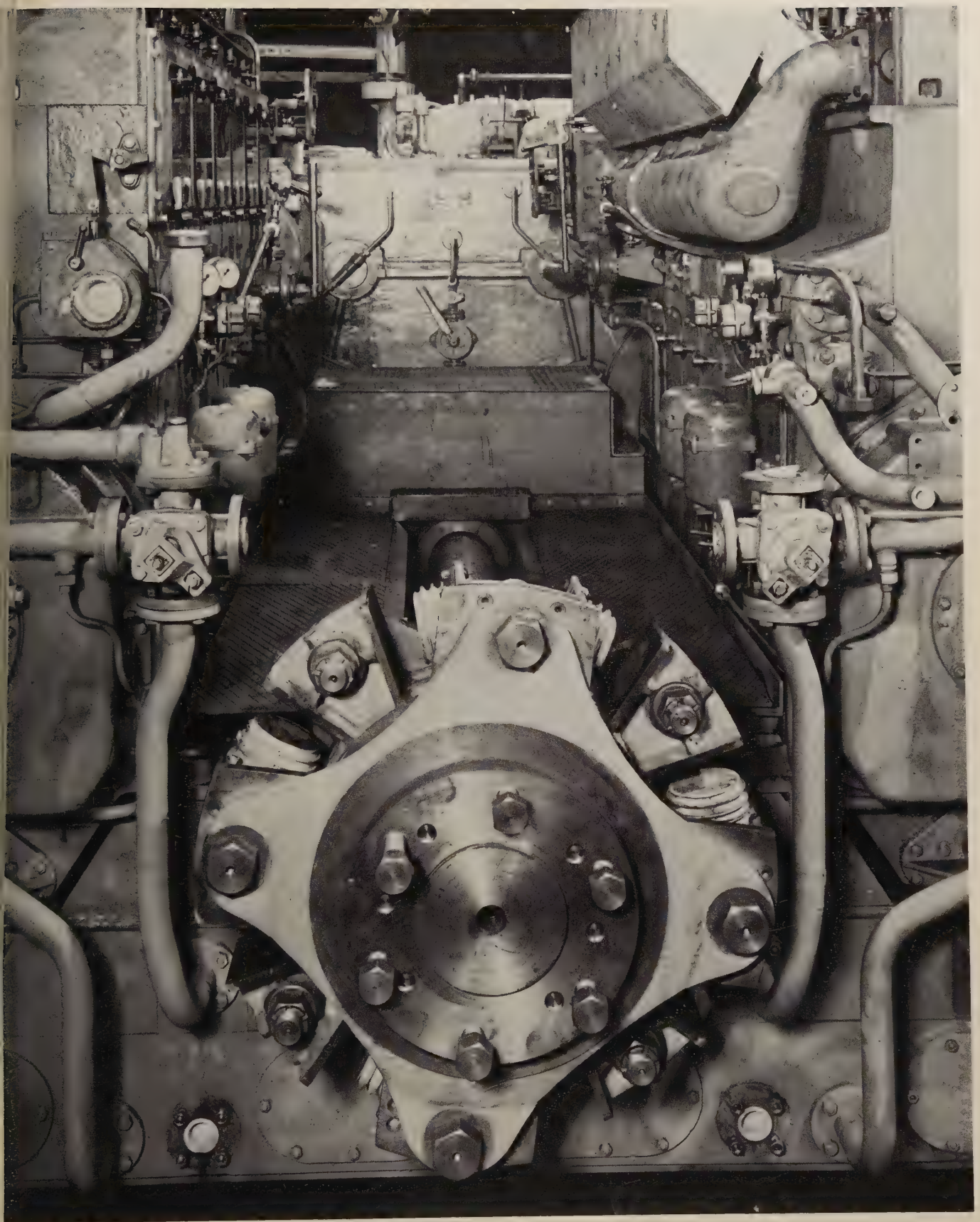
A constructional problem of the bow propeller installation delayed its satisfactory commissioning. Because of the total length of unit, including motor and pod, the manufacturers were unable to accommodate it in a vertical test rig in their workshop ashore for extension, retraction and rotation trials. The lowermost part of the supporting framework, the guides carrying the pod whilst extended, were therefore fabricated separately and had to be welded into the hull piecemeal. Misalignment was inevitable under these conditions and had the effect of preventing smooth extension and retraction and also rotation. When the guides had been aligned correctly, the unit proved to be most effective and has been used on several cruises, with more than sixty lowerings during one cruise.

Obviously, the design and construction of the supporting framework of such a retractable unit should provide for test and installation needs. Although these difficulties were foreseen and underlined during discussion with the manufacturers, and the cost of rectifying the defect was borne under the vessel guarantee agreement, disruption of cruises occurred until the defect was finally cured.

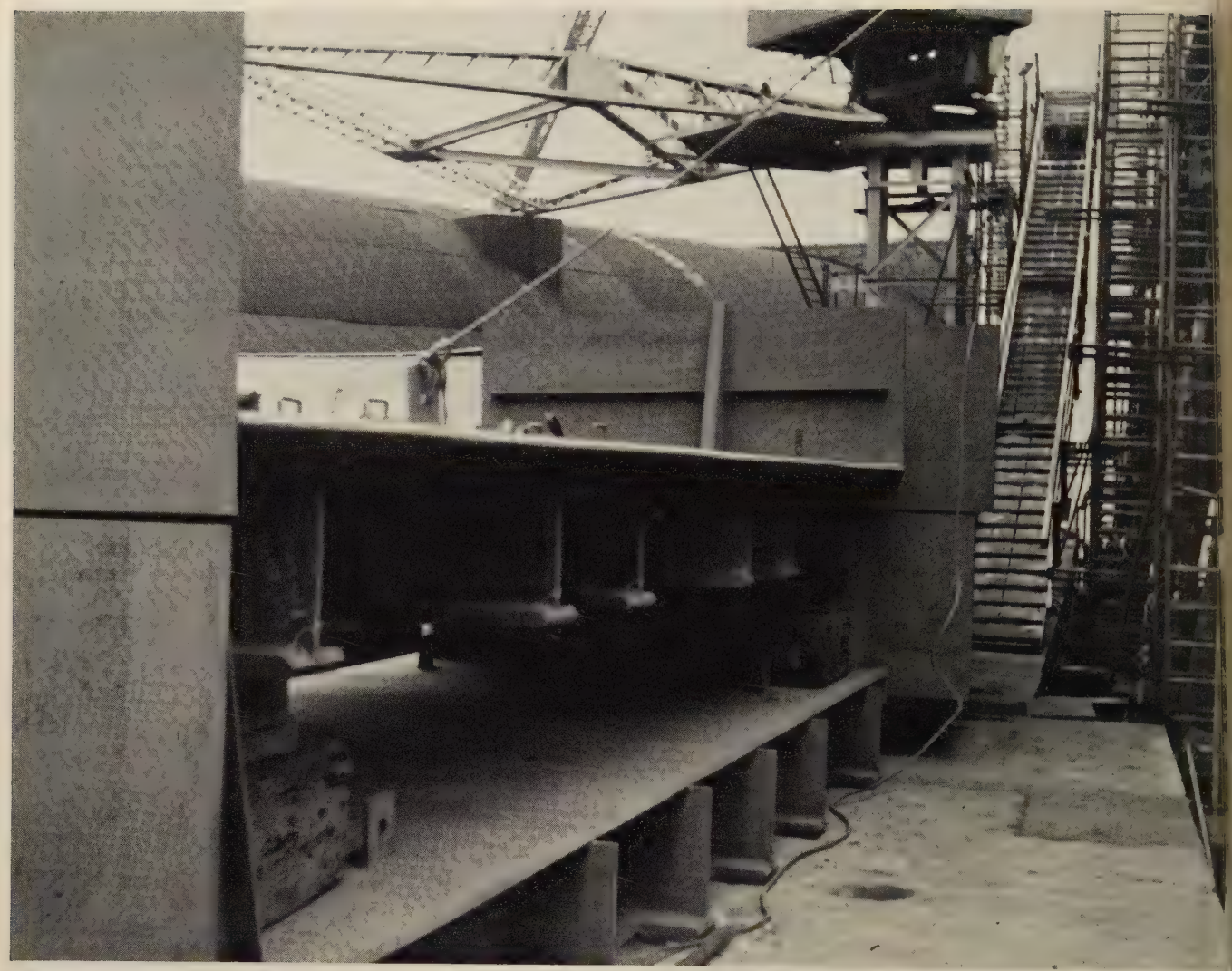
1 RV *Cirolana* (Crown copyright)



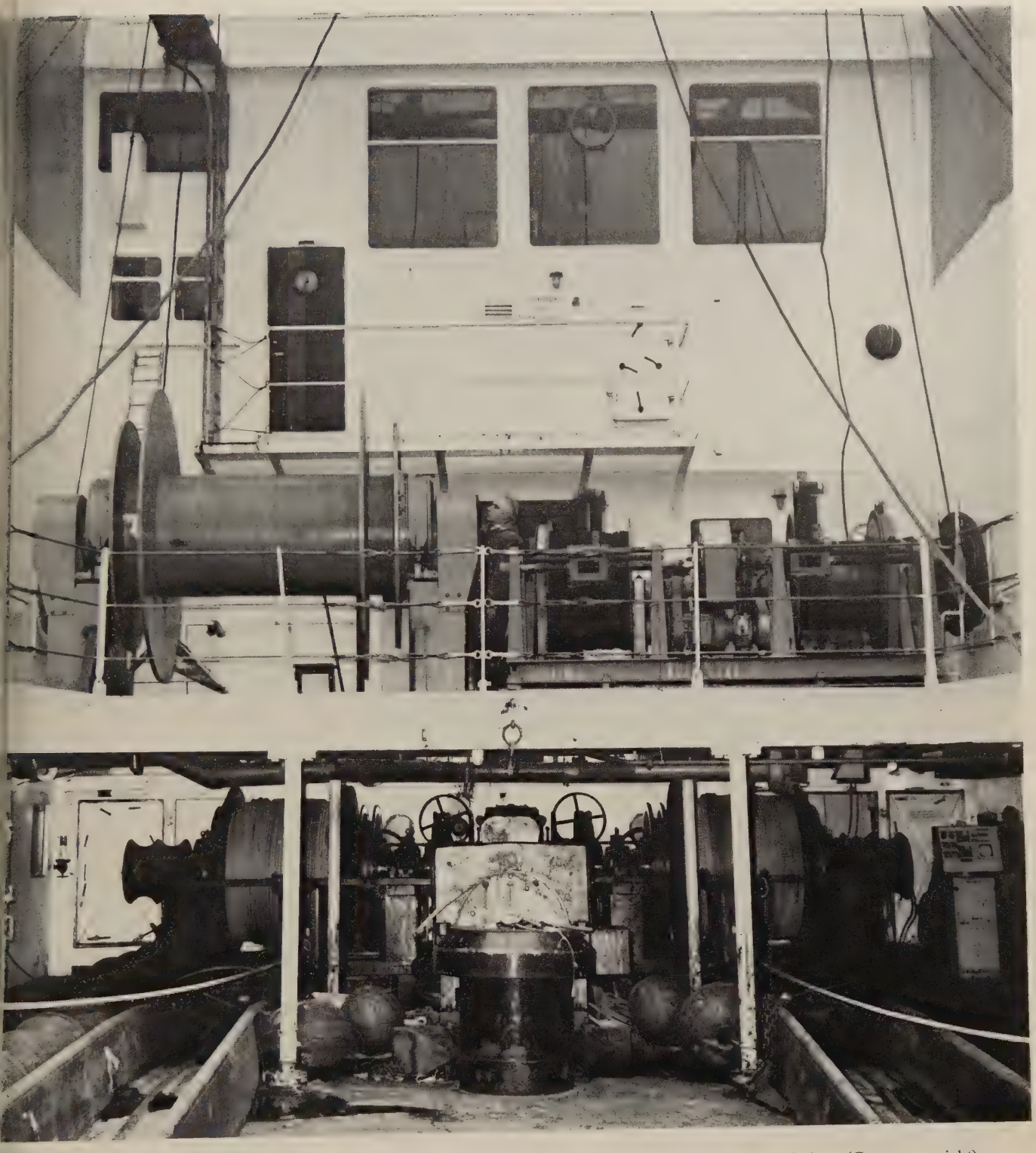
2 RV *Corella's* engines installed with gearbox on raft (solidly mounted on test bed – arrangement to W.H. Allen flexi...



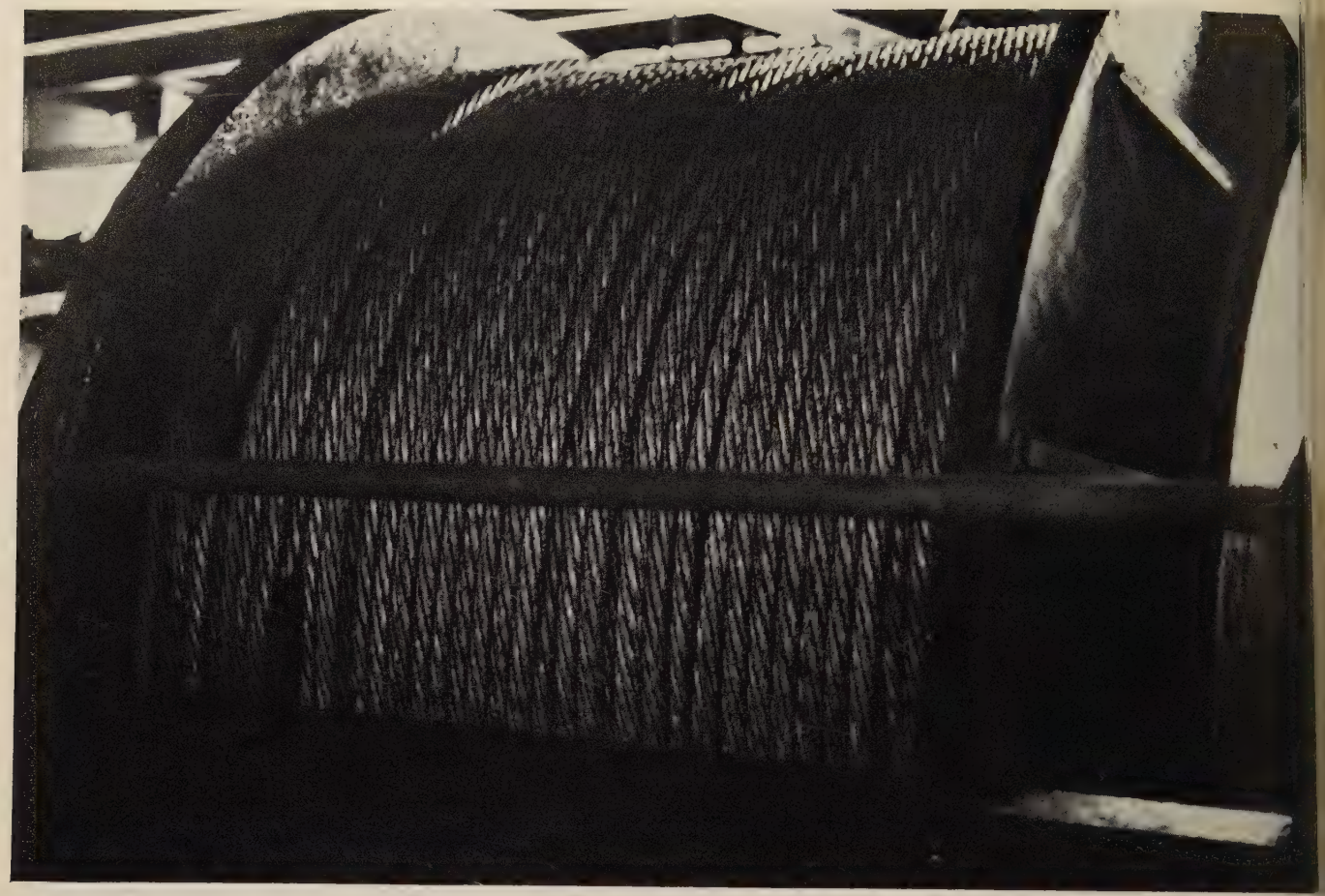
3 RV *Corella's* engine installation, after end to show flexible coupling on cardan shaft (acknowledgement to W H Allen Sons & Company Ltd)



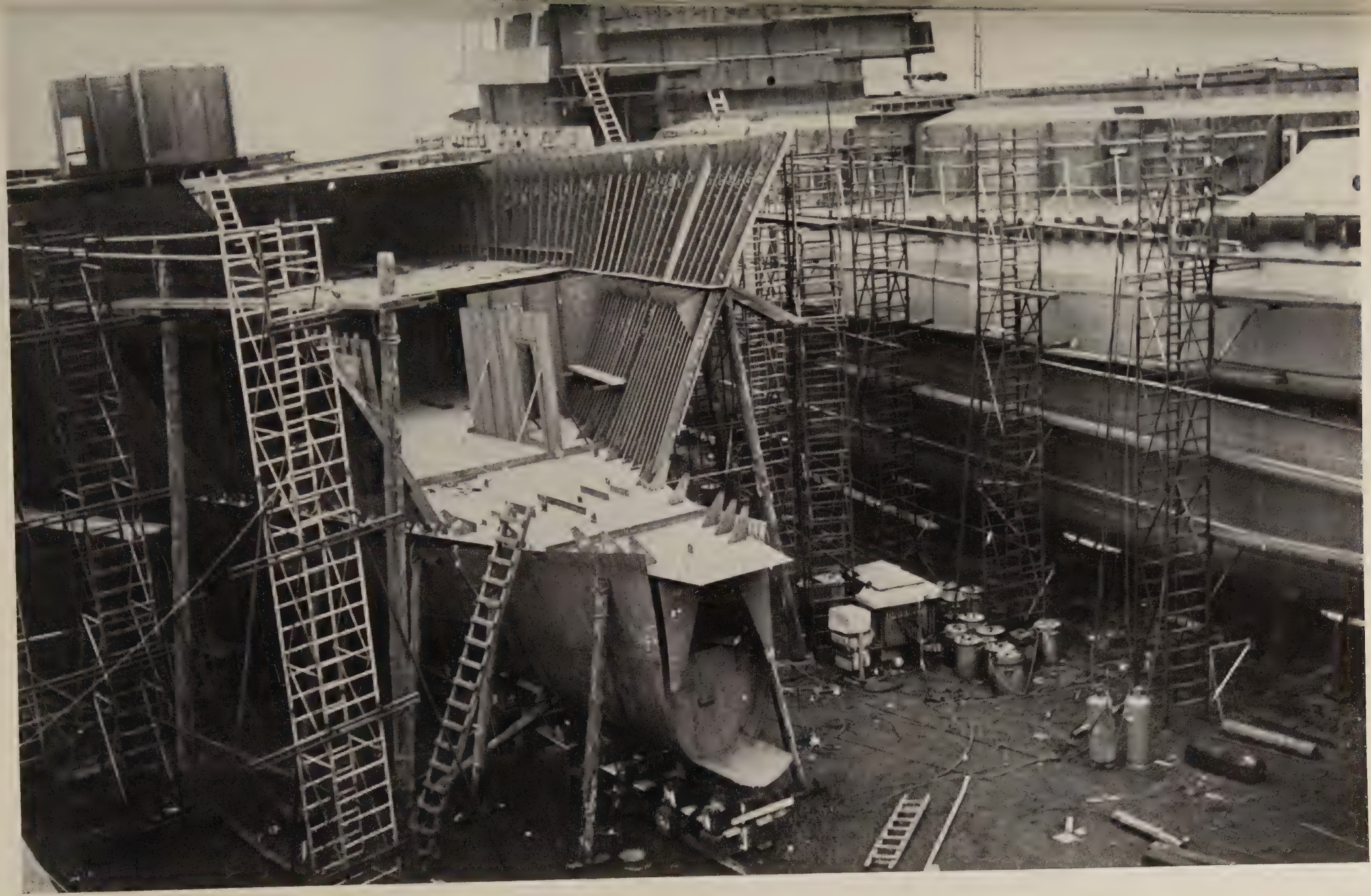
4 RV *Cirolana's* raft sections awaiting erection (Crown copyright)



5 Net drum winch installed alongside main cable winch at boat deck level on RV *Cirolana* below after bridge windows (Crown copyright)



6 RV *Cirolana:* main trawl winch, spooling by LeBus grooves on warp barrel (Crown copyright)



7 Double framing in area of maximum slamming (note after bulkhead of bow propeller compartment) (Crown copyright)

8 Forward starboard conning position with aircraft astrodome seen from after side of chart table (Crown copyright)

If manoeuvring away from a quay is an essential requirement, the recently devised rotating cylinder rudder may be nsidered (English and Steele 1970, Anon. 1971b, 1972) in ace of the Kort Rudder. When fully developed it promises have a dramatic performance and appears to be particularly effective for low speed manoeuvring, without, of course, e Kort Rudder's effect upon towing power (Chaplin and oster 1970).

D) BRIDGE WITH MAXIMUM VISION AND ALL SHIP CONTROLS

nlike the bridges of cargo ships or passenger liners described y Wilkinson (1971) as an historical development, fishing ver a stern ramp requires, automatically, that the fishing kipper can see the gear on and off the trawl deck, and all ommercial trawlers have a rear-view window, often with the hain winch controls and selected ship/engine controls adjac- nt. A research vessel would normally add to these basic eeds a greater expanse of after window to permit scientists o observe research gear being handled from the after deck. Additionally, hydrographic stations, which are carried out rom winch working positions amidships, require that the Officer of the Watch be able to adjust the vessel's position in rder to maintain a vertical wire. Good siting of bow propeller controls and a view of this wire are thus essential. The atter requirement is aided in *Cirolana* by the presence of an aircraft 'astrodome' (Plate 8). Launch and recovery of moored current meter stations from the fore deck require also that hese controls be sited to allow a clear view of the working space on the fore deck, near the rail, and of the water alongside, where the equipment enters and leaves the sea. Control consoles are sited, therefore, for operation from the bridge wings but are not positioned in them.

The compact and open-plan bridge layout with minimal frontal windage as originally conceived was complicated by the presence of twin funnel casings, which somewhat restricted the view of the ship's quarters. The presence of the 'stabilizer' tank immediately below the bridge deck required maximum width for efficient roll reduction and this caused the wheelhouse to become wider than required for its contents, even though these included a weather station, charting, navigational aids and a central control console, with fishing and sonar/sounder survey instrumentation, plus a radio room (Figure 13).

All the requirements were met and resulting visibility is good. The three deck to deckhead windows (Plate 5) permit simultaneous observation by a number of staff, without encroaching on the space needed by the ship's fishing officers.

Frontal windage is, however, more than desired, and is due to the presence of the twin funnels flanking the trawl winch, and the need to extend the width of the bridge to obtain a clear view of the quarters through the half-glazed doors. To have restricted the bridge width to lie within the funnel casings would have required either unprotected bridge wing control positions, which would have been entirely unsuitable for year-round station work in the Barents Sea or other cold areas, or control cubicles for the console and operator of such a size that windage would have been reduced only marginally and costs might have been higher.

The overall operation of the vessel from this bridge is satisfactory and the sunken siting of the radio room on the mezzanine deck level occupied by the passive stabilizer tank permitted good visibility over its low roof structure, which itself provided a useful bench for all radio equipment and reference books likely to be required by ship's officers, e.g. RT/VHF for ship to ship or ship to pilot station communication etc. Visibility from the central control console, used alike for fishing or passage-making, is unaffected by the presence of this radio equipment. Ample room exists for ship and scientific personnel.

The central control console and the forward bridge wing consoles for control of the bow thruster are seen in Figure 13. For all normal passage-making the vessel is controlled by the auto pilot and no one is needed at the 'wheel'. For fishing, manual control is used and the officer has all ship performance data, radar, sonar, echo-sounder and headline transducer records within a small area and convenient to the steering position. He can be joined by one or two of the scientific staff wishing to monitor a sonar survey or midwater trawl catches without mutual interference.

Normally only the starboard wing console is used when the bow propeller is operating. Extension, retraction and directional rotation of the propeller pod is controlled, and thrust varied, from the console.

Because of the physical distance between the forward bridge bulkhead and the main control console, which subdivides the bridge into forward and aft portions, the need for some duplication of ship performance instrumentation has been expressed, particularly for main propeller revolutions and ship's speed. These instruments should be sited adjacent to the Kent Clear View screens and the traditional forward position taken up by the Officer of the Watch during passage-making. However, visibility from the main console is entirely adequate to achieve safe passage-making if desired.

(d) PASSIVE ANTI-ROLL TANK

Initially this was required to be below deck, and to be of unrestricted dimensions so as to obtain optimum performance. Severe constraints imposed on ship length led to the tank being sited on the top of the accommodation deckhouse on the fo'c'sle deck and forward of the wheelhouse. Finally, following discussions with the consultants and the shipyard, the tank was resited below the wheelhouse floor, thus giving a slightly better angle of vision forward, over the bow, and also allowing a cleaner windage profile. Effectiveness of the tank was improved by the increased height of its installation (van der Bosch and Vugts 1966), and with about 16 tons of water, or <0.7 per cent of the departure displacement of 2,380 tons and a corrected GM of 2.30 feet (0.75 m), it provides a very satisfactory roll reduction of a little over 70 per cent at resonance in most sea conditions, provided that 'tuning' is carried out regularly. (Model forced rolling trials had indicated that up to 75 per cent reduction might be expected (Trout and Downham 1968) Figure 13 gives the outline of the tank structure.

After commissioning, a standard flowmeter was incorporated in the tank drainage so that gravity might be used to 'tune' the tank and remove the necessary weight of water as total ship displacement is reduced during a cruise. This simplifies the procedure of periodic removal of surplus water, and the calibrated pump is used for filling to required depth only. A sight glass cannot be used for tuning at sea because of the motion of the tank contents.

As fitted, the tank has a single central sight glass for determining water level as normally advised (Lewison and Williams 1972). Inevitably, a small and variable angle of heel is experienced when the vessel is alongside the quay, and two sight glasses, with maximum separation, are to be preferred, so that a mean depth of water can be determined readily. If even a small angle of heel is present, but disregarded during tank filling, several extra tons of water may be pumped in whilst bringing the contents to the, apparently, correct level amidships. This additional weight can cause serious increases of

roll angle even under moderate sea conditions, because the contents of the tank will tend to get out of phase. In bad weather such an overloaded tank could be dangerous and produce large roll angles. It follows that attention must be paid to the operating conditions proposed by the designers of the tank and that it must be filled to its correct depth of water and the appropriate weight of water removed, according to the progress of the cruise. The amounts will be dependent upon utilization of fuel and water or the launch and retrieval of major weights at any time during a cruise, e.g. moored current meter station equipment, of which up to 25 tons were allowed for in the designed displacement. The weight of water removed is required to be within 10 per cent of the theoretical amount, for optimum operation, wherever the tank may be installed (Goodrich 1969, Lewison and Williams 1972).

Under icing conditions at sea, up to approximately 70 tons of ice could be accumulated on the upper fo'c'sle deck and superstructure before *Cirolana's* stability is reduced to the point where the tank's contents must be dumped. Use of the water-ballast tank system could permit a further 70 tons of ice to build up before all stability is lost.

(e) IMPROVEMENTS IN HANDLING FISHING GEAR

Two basic requirements were the ability to fish bottom and midwater trawls alternately and with a minimum of time lost in their exchange. It was also desirable to be able to handle these gears, with a minimum number of men, on a deck shorter than the optimum and narrower than that of most commercial vessels, due to the presence of laboratories on the side decks (Figure 3).

At the time of planning *Cirolana* (1965/66) no experience of net drum winches was available in the United Kingdom and none was manufactured there. The provision made for the later fitting of such a winch—to be sited in the narrow arena which was left clear towards its after end—was the earmarking of switch-gear on the AC distribution switchboard and suitable for use with a motor of up to 75 kW.

West German commercial stern trawlers had been quick to exploit the pelagic trawl for herring and redfish but did not make use of net drum winches as a rule during the late 1960s. They developed, however, a method of carrying the Süberkrüb doors from towing blocks on swivelling brackets at each quarter, as well as the bottom trawl doors carried on the transom. In this way either type of trawl could be deployed as required. This method was adopted for *Cirolana* with four innovations:

(a) Swivelling brackets were replaced by fixed supports for the quarter towing sheaves.

(b) Warp tension meters were considered essential and required a warp 'wrap-round' angle of 168° (WFA 1970) on their hanging sheaves, some 10 feet (3 m) above the deck.

(c) The grooved drum method of spooling (Waters 1920, Bellamy and Phillips 1969, WFA 1971) was incorporated into *Corella's* split winch design in 1963 and had proved most effective (Anon. 1967). If used on *Cirolana's* main trawl winch barrels it promised to minimize the number of crew required at the winch when heaving in the warps.

(d) A 'fixed point', to determine the correct fleet angle for the LeBus grooved drum and to permit the change of direction of warp from after towing block to quarter towing block, was achieved by a simple combination roller/sheave on the mast, immediately abaft the tension meter block. In this way the deck was freed of the deck bollard and sheave commonly used commercially for the change of warp lead (Figures 2 and 3).

The fishing system has operated successfully for both types of trawl, the catch being handled on the port side deck, without the net drum winch being installed. The large number of heaves required to stow the Engel 2000/788 herring/cod net, however, led to the adoption of the Engel 1600/572 trawls as standard sampling gears, and the net drum winch was designed to accommodate these nets. Although designed to be sited in the narrow arena, the net drum winch was finally installed on the boat deck, alongside the main cable winch (Plate 5), thus removing the need to provide remote control for the main winch because of the resulting reduction in visibility from the main winch operating platform. The LeBus spooling on the latter has been effective throughout and its smooth pattern persisted even when a new 400 fm (730 m) length was spliced on to the old warp for fishing to 650 fm (1,280 m) (Plate 6). The position of the splice can be seen in successive layers but spooling remains satisfactory. For optimum spooling (Anon. 1971c) single lengths of warp are normally advocated for this system.

LeBus-grooved split sleeves were fitted to the main warp drums of an otherwise traditional 'bought in' four drum winch, i.e. not specially designed except for the rather narrower than usual drums to permit the winch to fit into the available deck width. Failure of the warp drum flanges, during an early cruise, led to their replacement by new flanges of increased strength and thickness (Figure 14). At the time of the flange failures, Mr Siddle of the WFA calculated (pers. comm.), from a 1938 formula by Roark (Roark 1965), that a total end load of 587 tons built up on the flanges during the recovery of a trawl from maximum depth and at normal speeds (see also WFA 1971). It would appear, from the frequency of flange failures on commercial and research winches, that, although Roark's formulae are of long standing, the calculations are rarely applied by traditional trawl winch manufacturers or shipyards. (The new flanges fitted to *Cirolana's* winch, however, are not typical of LeBus' current practice. Split sleeves are now provided with webbed inner flanges, ready to be welded to the inner surfaces of the existing winch flanges, to provide them with the additional strength required to counteract the end loading.) Costs of rebuilding the winch drums were covered by the guarantee clause of the contract, but disruption of cruise programmes resulted.

When operating both types of trawl the cod-end is brought up the ramp by means of tackle or gilson, operated from the twin whipping drums as convenient, port or starboard. The cod-end knot is untied and the catch is tipped out on to the port side deck to be dealt with as required in the wet fish laboratory. Surplus fish, benthos, rocks, etc. are disposed of either down the ramp or overside through a 'dumping' port.

The space available on the trawl deck has been criticized in comparison with that of some commercial vessels and is due to the constraint on ship length. It is, nevertheless, entirely workable. The major limitation experienced prior to the fitting of the net drum winch, and one common to commercial trawlers without net drums, was the time taken to dispose of the bottom trawl and bobbin groundrope, which had to be dismembered and stowed (below deck in the case of *Cirolana*), before the midwater net could be handled. This operation and the reverse required 5–6 hours. With a net drum installed (in either the arena or boat deck position) the midwater trawl can be shot over the bottom trawl stored in its normal position on deck around the arena. For this reason the midwater net winds on to the top of the drum. Exchange of nets requires only the lead of the warp to be altered and shackled to the appropriate doors, and the time for this should approach that experienced in Norwegian and Canadian commercial vessels, viz. 20 minutes; furthermore, fewer men are needed to handle the midwater trawl. The net drum winch is not designed to handle the bottom trawl on *Cirolana*.

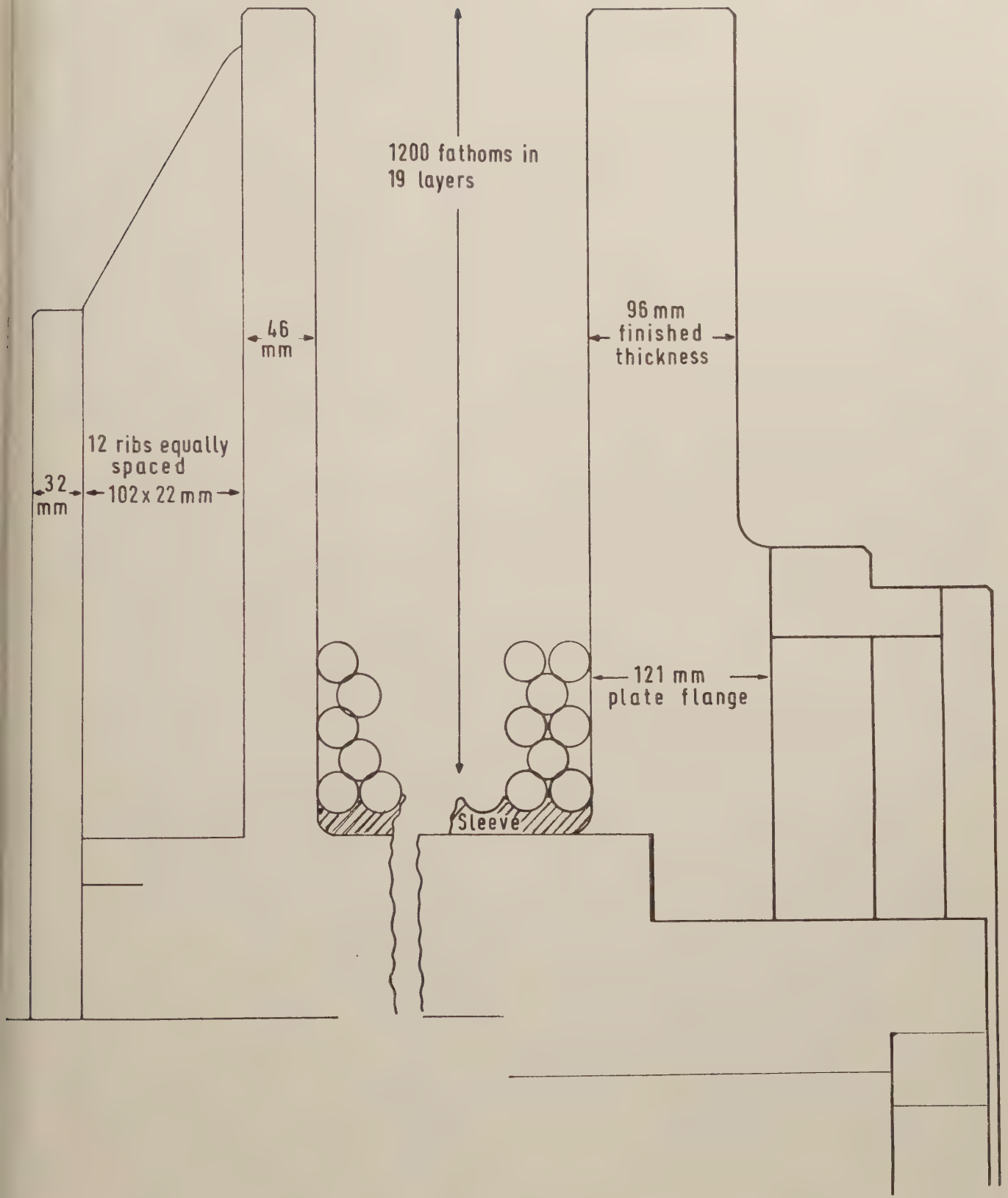


FIG. 14 Diagrammatic section through main trawl winch warp drum after strengthening (with acknowledgements to LeBus International Engineers Limited).

(f) CONSTRUCTION

A small number of constructional matters require some comment.

(i) Reference to the lines plan shows that the after sections of the hull are not swept smoothly from the hull to the keel but that the plating is built down to a sharp welded 'tuck' in order to avoid furnacing the $\frac{3}{4}$ inch (19 mm) thick plating. This method has not yet been found to produce increased underwater radiated noise owing to increased turbulence in the flow along the after waterlines, and thus it appears to have been an acceptable economy.

(ii) Because it was simpler to construct the ramped stern is straight instead of being given the more normal curved section. A curved ramp would have given more headroom in the steering gear compartment, but the straight section is not thought to have contributed, to any significant degree, to the ability of the seas to run up the ramp and so make the after deck wet. 'Green' or 'solid' water is sometimes taken up the ramp by most stern trawlers even in quite moderate weather, particularly when they are trimmed for fishing, with the lower end of the ramp immersed to facilitate heaving the cod-end inboard without damage on the ramp kunckle. The presence of the usual wave gates reduces the weight of water taken on to the after deck and hence reduces the risk of damage but in bad weather and when on a particular heading sea water penetrates to the area around the trawl winch. On *Cirolana* direct overside drainage is limited to the starboard side deck, i.e. around the hydrographic winch and platform. The port side is occupied by the store and the Clean Biological Laboratory (Figure 3). Really adequate scuppers are therefore essential, for any such partially enclosed area of the main deck, to permit the water to drain away quickly. A vessel's sheer will ensure that any water, including rain, will drain forward towards the winch, taking with it debris from the catch or from net mending undertaken on the trawl deck. Scuppers must be provided, therefore, with readily accessible strainers. On occasion, a mean depth of approximately 4–6 inches (10–15 cm) of water results from a wave running up the ramp. That water does not drain away fully before the arrival of the next wave, despite the presence of two enlarged scuppers (6×4 inches–15×10 cm) on the port side, unless the vessel is given a slight list to starboard, so that the water can roll clear eventually. Stiff sheet-rubber 'skirts' fitted to the lower edges of the wave gates would probably prevent most water from reaching the deck except in bad weather.

(iii) Avoidance of seawater penetration into main deck laboratories is also a major problem in a ramp-sterned vessel. Because of a demand for low sills to permit easy handling of heavy or bulky equipment at sea the main laboratory's double doors were provided with sills of 6 inches (15 cm) and hence of less than regulation height. These tend to be inadequate at sea if the doors must remain open during bad weather. A preferable solution would be the provision of full (regulation) height, but removable, sills, in place of the present low sills, for use in port and during calm weather at sea.

(iv) Fore and aft distribution of water ballast tanks was called for, which would permit changes of trim to be achieved as appropriate between the free running design trim of 1.5 feet (46 cm) and the maximum attainable for fishing (5 feet, 152 cm). The latter trim has not been used, 4 feet (120 cm) usually being adequate. Any intermediate trim can be selected and reproduced when required by filling/emptying appropriate tanks irrespective of the stage of the voyage. Reproducibility of trim and heel conditions is important for comparability of acoustic survey and for development work on acoustic instrumentation.

For passage-making, trim must be returned to the design free-running condition because immersion of the ramp increases ship drag materially. For short-distance movements as for example on a fishing ground, this is unimportant, but no long passages at normal service speeds should be undertaken with the ramp deeply immersed (Heinsohn 1964). The vessel should be retrimmed as appropriate for her current mode of operation.

(v) Provision of a standard shore-type Belling and Lee Screened Cubicle for some sensitive research equipment required more headroom than could be produced in the Main Laboratory (Figure 3) if normal vessel construction, based on an 8 foot (2.4 m) distance between the steel deck surfaces, was used. However, by eliminating the camber of 6 inches (15 cm) from the deck in the Main Laboratory, sufficient height was obtained to permit the cubicle to be erected without altering the slope or depth of the beams of the deck above. The camber was reduced gradually from a point on the main (fishing) deck just aft of the main trawl winch motor. The sheer was not altered, being common to all decks. Installation of modular bolt-down fixings, in the form of non-corrosive drilled and tapped metal strips recessed into the Main Laboratory flooring, running athwart-ships was simplified by the absence of camber.

(vi) Strengthening of the forward sections of the hull, by reducing the frame spacing, so called 'double framing', (Plate 7), and also the provison of fore and aft supporting frames, has so far enabled the hull to maintain its shape in the area of maximum 'slamming', although inevitably severe head sea conditions have been experienced. However, despite the $\frac{3}{4}$ inch (19 mm) plating and doubled framing forward, the small bulbous bow has suffered in light ice and has been slightly flattened on one side.

(vii) The ship was planned to lie starboard side to the quay at her permanent berth on the port of Grimsby. As no cranes are installed at that quay, a low-pressure hydraulic 'boom swinger' for the 7 ton starboard derrick was called for in the Statement of Requirements and in the Hull Specification, to provide a degree of self-sufficiency in handling heavy scientific equipment and engine-room stores, particularly abroad, but also in her home port. In addition to the derrick and after winch, which can handle the heaviest single item of gear on board, namely a 1,200 fathion (2,200 m) coil of trawl warp weighing more than 5 tons (5,600 kg), a mechanical stores and equipment lifting system was considered desirable because of the vessel's high freeboard, which would limit the weight of items capable of being manhandled over the rail.

Financial pressures led to this facility being omitted, and a possible alternative light lifting device amidships, the starboard workboat davit, proved unsuitable because of low 'light load' pay-out speed. Laboratory transport, equipped with an articulated jib-crane, has, however, proved entirely adequate for most routine storing needs. Shore mobile cranes are hired for the heavier gear, otter doors, warps and the like.

The twin forward baggage davits allow storing to be carried out irrespective of which side of the vessel lies to the quay and they can also be rigged for the towing of echo-sounder transducers.

(viii) Uncertainty during building, over the operation of moored buoy supported current meter stations from *Cirolana* led to her being commissioned without the necessary handling facilities on the fore deck. However, power supplies were provided for a self-contained electro-hydraulic articulated jib crane with integral winch, and a removable, low-pressure electro-hydraulic buoy winch (on the 'FLASH' principle—Dermody *et al.* 1968). Additionally, the starboard ship-side plating at the after end of the buoy store, below the fo'c'sle, was kept clear of all services so that a side-opening door could be fitted if required when policy and handling method for the current meter stations were finalized.

(ix) The stabilizer tank was built on the normal structural deck and was thus provided with 6 inches (15 cm) of camber. It required recalibration to reach its expected performance and the weight of water carried was reduced from 20 to 16 tons. Its operation in beam seas is effective but noisy and an effective system of energy-absorbing baffles to reduce impact noise, which is most apparent on the bridge, is required.

(x) There are three systems of cable ducts: a) one system links all laboratories, engine room, bridge, weather station, cable winches, and net-sonde winch on after gantry, to the Data Logger/Computer Centre in the Plotting Room; b) hull-mounted transducers' cables reach the forward bulkhead of the Plotting Room via pipe ducts, to permit easy exchange of these cables, and, in addition, a duct runs forward for cables of echo-sounder transducers towed from the baggage davits on the fore deck; c) winch motor power cables are run in separate pipe ducts to minimize electrical interference in the slip-ring cable circuits of the three research (cable) winches and the standard net-sonde winch installed on the after gantry.

(xi) Safety regulations relating to trawlers do not include a construction able to combat 'single compartment damage' (Trout and Downham 1968). As described in that paper *Cirolana's* large engine room has watertight doors in the forward and after bulkheads. These bulkheads are also extended vertically and so subdivide the accommodation (lower) deck. Watertight doors are provided in all alleyways. Damage to the engine compartment, which might lead to flooding of these alleyways would cause these doors to be shut by the pressure of water: they all open inwards towards that compartment. Even in the departure (deep load) condition, depth of water on the lower deck would not exceed 2.5 feet (0.75 m) and an adequate stability would remain, once the stabilizer tank contents had been 'dumped' through the overside dumping valves.

Smoke doors are installed to comply with the Holland-Martin Report (1969).

(xii) Wherever practicable, provision for the addition of future equipment with a major shipwork content should be made during the design and construction of the vessel, even if the equipment will not be installed for some long period. In this way the additions can be carried out with a minimum of disruption to other research and ship systems, and thus at minimal costs. To give only one example of the several provisions included in *Cirolana's* design (Trout and Downham 1968), the installation of the sector scanning sonar trunk (Mitson and Cook 1971), which extends from upper deck to plate keel, was a simple undertaking during building. To have planned the vessel 'for but not with' the tube would have run the risk of finding many services routed through those areas, because no overall planning is normally undertaken for the fitting-out stage of building. To try to install such a tube some years after building without having planned for its introduction would incur considerable costs for cutting out and making good ship structure and research and ship services.

(xiii) Provision was also made to carry a small, standard (16×8×8 foot) container laboratory on the starboard deck. An early proposal was to equip such a container with high through-put blast tunnel quick-freezer units, for use during cruises where novel fish species of potential interest to the fish trade could be frozen. Storage would be in the fish-hold which can hold up to 35 tons at —20°C. Loading from deck to fish-room and from ship to quay would be by 'union purchase' using the two derricks and the after winches.

Consultancy options and contracts Those used for *Cirolana*

(i) Unlike Australia and Canada, the United Kingdom has no Government civil ship design agency which will undertake the development of the design of a projected vessel for another Government Department and through all stages of building to trials. The Ministry of Defence (Navy) is, of course, its own design authority for the highly-specialized fighting ships and their contained weaponry.

The Australian Shipbuilding Division of the Department of Transport offers such a design service and will undertake each stage from the initial discussions of intent to the final design (including model tank testing, supervision of construction and acceptance trials) on behalf of a sister department. This service is also available to commercial operators.

The Canadian Department of Supplies and Services does not have all those facilities and carries only a limited drawing office staff. Its design personnel, however, will undertake feasibility studies for any project and the Department will appoint the most suitable private firm of consultants and also provide overall responsibility for the suitability of the design and an inspection service during building and at trials. Use of this service is mandatory for all Government Departments.

In the United Kingdom, on the other hand, a number of options are open to the department wishing to build a new vessel, provided that HM Treasury requirements on tendering procedure for the actual building contract are met. These options include:

a) Selected shipyards may be invited to submit proposals for a design to fulfil a specified set of requirements, together with a tender for building to their own design; alternatively, one of the designs put forward could be used as a basis for tendering by the other yards.

b) A firm of consultant naval architects is sometimes asked to undertake a design study only, which will be used for tendering purposes. The consultants then play no further part, because their contract ends with the issue of tender drawings and specification. As no provision is made in this form of contract for the analysis of tenders, approval of shipyard drawings and inspection of materials and construction, a further firm of consultants may be contracted to undertake these duties, or the user organization's marine staff may be able to take this responsibility.

c) On occasion, the local Lloyd's Surveyors will provide a limited inspection service and this is utilized in some cases.

d) For any sophisticated 'one off' design of research vessel, the most logical procedure is to appoint a firm of naval architects and marine engineer consultants contracted to provide a comprehensive service as already outlined earlier. Such a service brings a consistency of approach to the whole design, plus the experience in arbitration, should need arise during the building phase. All other methods can be seen to have the obvious disadvantages of divided responsibility for the overall suitability of the design, and to increase the number of potential points of breakdown in communication, and thus provide obvious risk of dissatisfaction for the users. Again, if the user's marine staff can provide the required level of design expertise, then the control of its development remains that much nearer to the user. However, few fisheries laboratories are fortunate enough to carry a naval architect on their staff, and the importance of employing a main consultant becomes even greater when novel design features must be included, each of which requires its own specialist consultant. Such components as anti-roll stabilization tanks or a noise-reduced engine installation lie outside the normal design expertise of general consultants, although the principles are, of course, well known to them. The inclusion of these special components must be accomplished as part of an integrated development of the overall design and not just added piecemeal.

It follows, therefore, that the design of each of these and other major components should be initiated as early as possible, that is when the basic vessel parameters are crystallizing, so that any need for modification and refinement of their design may be controlled by the consultants and result in a single design entity of compatible elements. The contract between the consultants and the user department should include a clause, therefore, providing for all specialist design consultants to be engaged by the former for agreed projects, and should also allow later, for example, for supervision contracts for special installations, such as the noise reduction measures.

e) A procedure often used for the procurement of cargo vessels, tankers, container ships and the like, provides for another ship-owning company to design, build and crew the vessel on the understanding that the organization commissioning her will charter her on a long-term basis (10- or 12-year charter contracts may be signed before the vessel is built). This procedure represents a method of obtaining new tonnage without caiptal cost. To be commercially viable for the company providing the capital, however, the vessel must be of a type certain to be in demand when the original charter contract expires. As a method of obtaining a fisheries research vessel with any degree of sophistication it will be seen to have many drawbacks. To obtain an entirely satisfactory design would require the same degree of involvement of the research institute with all stages of planning and detailing, with the additional disadvantage of another potential communications hazard, namely the board controlling the capital expenditure. The chances of chartering of the vessel in turn to other research organizations with interests sufficiently similar in terms of fishing gear might not, perhaps, be too difficult. To be able to provide for all other research services, however, to suit the range of users contemplated, would constitute a major difficulty of design compromise, and high capital cost would appear inevitable. At the same time, the size of the resulting vessel could well be an embarrassment to each potential user. In the writer's opinion, only the simplest kind of research vessel could be obtained by this method, and if any specific fishing gear were to be required, a charter of a specialist fishing vessel and crew would be, in all probability, a more economical solution, with the advantages of being able to select a different vessel, with gear and crew experience appropriate for each project proposed.

(ii) At the other end of the scale, the writer has advocated (Trout 1974) that the duties of the main consultants should be extended into what, traditionally, has always been shipyard responsibility, namely that all research and ship services should be planned on the drawing-board under their control and not left to piecemeal unplanned installation during the fitting-out period. Only in this way can the many research systems be incorporated into the vessel in such a manner that they can be reached easily for routine inspection, maintenance, repair and replacement at the requisite timings, without major costs arising from cutting out and making good the surrounding shipwork or services installed later in the sequence of building.

For the 'one off' vessel this appears to be a novel proposition, but discussions with shipyard personnel and consultants indicate that it is entirely practicable, and might even be welcomed. It is, of course, not unknown in other countries, al-

though it is more usual in series shipbuilding. Obviously some preliminary indication that this planning procedure is required would need to be introduced into the 'proposed form of contract' included with the building tender documents. In the specification, and on the general arrangement drawings, an outline of what is required for each service must be included so that subcontractors may be warned and hence be able to tender realistically, and with a minimum of 'extras', before the final details have been worked out between the consultants and the shipyard drawing office.

No doubt the risk of increased first cost would be criticized because the proposal is novel. Fortunately, however, realization of the value of low maintenance costs derived from good design and maximum reliability, by inclusion of the best components, is spreading. These factors give rise to a more satisfactory 'total through cost' (i.e. development, plus procurement, plus running, plus maintenance costs over the vessel's operational life of over 20 years) which should, of course, be the basis of technical choice (Dymoke 1972) instead of the still predominant selection by first cost.

(iii) It is traditional to include a lines plan of a vessel with the tender documents. For a research vessel, however, those lines should be looked upon as preliminary only, since they are based on estimated weights. The fine underwater form will be particularly sensitive to fore and aft weight variation (Doust 1963, Trout 1974), so that weight differences arising from different constructional practices between shipyards could affect significantly design characteristics and behaviour. The timing of model trials, therefore, becomes important and it would seem prudent to set down in the provisional form of contract, which is sent to the shipyard with the tender documents, that model trials would be carried out only when all weight data, including those from subcontractors of heavy items, have been determined. If all model trials are carried out on the basis of first weight approximations, a second series of model trials may well be required because of differences between weight estimates and final data—particularly when such major items as winches or diesel engines have not been specified or finally selected, or, as could happen with the former, not even designed at the time of estimating weights. No delay need be incurred by using this procedure, provided that tank time is booked ahead.

(iv) In many cases equipment selected by shipyards is included only on the criterion of lowest first cost, and frequently unsatisfactory operation becomes apparent after the guarantee period has expired. If experience at sea has demonstrated convincingly that a particular firm's equipment gives good performance and trouble-free service, it would appear sensible to specify such equipment to be built into the vessel in the interest of long-term economy. In the commercial world it is commonsense practice. On occasion, however, it may be thought desirable to include alternatives, but the wording of the specification should be written so that the user retains the final choice and the builder is in no doubt which manufacturer's equipment is preferred.

(v) The Ministry entered into a contract for a comprehensive consultancy with Messrs Rendel, Palmer and Tritton's Marine Section for both *Corella* and *Cirolana*. Specialist consultancies were also sought for their hull forms, to take advantage of any research developments by the National Physical Laboratory, Ship Division, Feltham for the stern trawler hull following the earlier work on the side trawler form (Doust and O'Brien 1959, Doust 1963), and for their passive anti-roll (stabilization) tanks (Goodrich 1969, Lewison and Williams 1972).

(vi) The Lowestoft Fisheries Laboratory arranged a contract, early in the preparatory stage, going directly to the Yarrow Admiralty Research Department—a section of Yarrow Shipbuilding Limited—for the noise suppression measures to be included in *Cirolana*, because of the long time known to be required for their design study. Messrs Rendel, Palmer and Tritton, however, were asked to arrange with Y-ARD a separate contract to supervise the installation of the noise reduction equipment, raft, resilient mounts and hooding of the engine installation, in view of the unusually stringent precautions necessary to avoid noise 'shorts' during construction.

(vii) The need to build vessels to the appropriate provisions under the Merchant Shipping Atcts, loosely referred to as Board of Trade (now the Department of Trade) requirements, is mandatory and most vessels are also built to (or in excess of) Lloyd's Register of Shipping current requirements for the appropriate class of vessel, although this is not mandatory. The Ministry has always considered that Lloyd's regulations should be followed, although, of course, British Government vessels are not insured.

Effect of management on design

Many of the earliest decisions taken when formulating the basic needs of a new vessel are related to the way in which an organization proposes to 'manage' her. These decisions include: the geographical areas in which research will be undertaken, arctic or tropical or both; the research programmes themselves, i.e. whether the vessel must be multi- or single-purpose, for multi- or single-aim cruises or even, unusually (Currie 1963, Medvedev 1968), for expedition-type operations of long duration; the ship's personnel, i.e. the number of scientific staff to be carried and the size of the crew to man her; the personnel ashore, who will arrange for the constant servicing of the vessel's fabric; the updating of her structure, and her life-saving and fire appliances, to comply with changing maritime regulations.

In this context, therefore, management is considered to be composed of three interrelated elements which, are, in practice, inseparable and upon which the entire design depends. These are: (a) *The operational control* of the vessel and her deployment to fulfil the research aims for which she is built. It follows that this control will be exercised by the scientific staff, who will also be responsible for alterations and additions to the research equipment content, the constant change and updating of which is one of the facts of research vessel life. (b) *The maintenance* of the vessel to keep her in a seaworthy and serviceable condition, which is undertaken, usually, by the laboratory's Marine Superintendent or, alternatively, in some other countries, by a centralized Government agency which is responsible for the maintenance of all vessels for all Government Departments. Under these latter conditions it is imperative therefore, that programming of cruises remains firmly in the hands of the laboratory and that refits, dockings and the like are timed to suit the cruise dates planned as most suitable for the overall research programme. (c) *The provision of basic shore facilities* to simplify the organization of (a) and (b) above and to make the operation of the vessel more convenient for both the scientific and the marine staffs.

(a) *Operational control*

For the most part research into commercial fish stocks tends to be undertaken from research vessels of a size similar to that of those vessels exploiting the species. These research vessels usually take a multi-purpose form. Whilst their capabilities include, automatically, fishing with bottom and mid-water trawls, with gear comparable in size and weight to that of their commercial counterparts, additional winches and sampling instrumentation also permit investigations into plankton, benthos, and underwater photography, as well as into the physical and chemical environment, for which fully-equipped fisheries oceanographic (or hydrographic) facilities are provided. Furthermore, as the writer has already indicated (Trout 1974), within this general-purpose framework each institution will build-in equipment which reflects its differing priorities and emphasis of interest in particular fields of work. Thus *Cirolana* was conceived as a 'quiet' vessel, noise-reduced over a wide frequency range, to enable both fish behaviour studies and acoustic surveys to be carried out. *G. O. Sars*, also concerned with acoustic surveys, was planned around a sophisticated integrated sonar/sounder survey instrumentation and computer complex, whilst still being capable of undertaking the more straightforward trawling and purse seining (Dragesund *et al.* 1968, Gerhardsen *et al.* 1968, Jar 1968). According to Craig (1968) *Scotia's* major task was a programme of fishing gear research, requiring a fully-instrumented trawl and a shipborne data logger/computer; considerable plankton and oceanographic sampling and survey work were also indicated in her layout. All three vessels however, may be classified as having similar biological and regulatory research aims relating to North Atlantic fisheries.

(i) *Personnel*-Emphasis on the ability to fish is reflected in the crewing of these vessels, which is largely by fishermen, and indeed a full fishing crew was considered essential for *Cirolana*. In determining the final crew structure two problems arise: firstly, if the gear is to be handled on a 24 hour basis, as on a commercial vessel, three watches are required; in the absence of provision for fully mechanized, remotely-controlled gear handling, and limited deck space precludes the use of storage drum winches for all gear recovery duties (Anon 1973), eight men are required on deck because of the weight of wires and auxiliary hardware; secondly, if crew size must be minimal then a small reduction could be made by handling the trawl doors in sequence, instead of simultaneously (WFA 1972); a small but probably acceptable increase in handling time would result.

The number and composition of the scientific staff to be carried will depend upon the total sea-going staff available at the laboratory and upon how the research programmes are organized, i.e. whether individual research projects predominate or whether multi-discipline teams are channelled to a given area for a period of some years on a joint, comprehensive project (Graham *et al.* 1954). If the average number of days which the research vessel spends at sea each year is taken to lie within the practical limits of 220–230 for the *Cirolana* size of vessel (FAO 1968), the drain on the sea-going staff can be calculated and the staff size adjusted or the number of berths planned according to the annual contribution expected from each staff member. Some allowance for growth of staff numbers must be made, plus some provision for the probable requests for sea time from students and visiting scientists.

Vessels of the size of *Cirolana* are expected to operate in all northern distant-water areas, and for example in the South Atlantic. Most fishing skippers become specialists in particular areas for particular species and cannot be expected to be experts on all grounds visited. Accommodation is required, therefore, to permit a specialist skipper to sail as adviser on special cruises, for example to the South Atlantic grounds, or with gear of which UK fishing personnel normally have no experience. This is always a difficult management problem, often aggravated by the high fees required by commercial specialists compared with the salaries of the ship's officers.

The larger vessels operated by the Lowestoft laboratory have carried, traditionally, a Merchant Navy Officer as Captain and another as Navigator. This practice had been maintained, earlier, largely to provide the high degree of accuracy in celestial navigation required for many research programmes. Even now, when still greater accuracy is provided by the several short/long range and satellite navigational systems available, which together offer world-wide coverage, these two officers are retained, in a non-watchkeeping but a '24 hour availability' role, for a variety of administrative duties, which, if included with the monitoring of navigation duties, would be unduly onerous for one officer. In these circumstances, this part of research vessel staffing requires clear enunciation of the limits and overlap of each officer's duties and responsibilities, and each country appears to require a somewhat different solution, depending upon local conditions and the traditions of the establishment and service.

The selection of officers whose temperament will fit into the small-ship community is seen by the Royal Navy as being as important as their professional suitability, and many of their appointment boards include psychologists. Although quite impractical for the small needs of fisheries research appointments, the value of happy ships' officers/scientific

'aff/crew relationship is unquestionable and is fundamental the successful operation of research vessels.

Under personnel matters must be included the problem of hether, or how far, to automate the engine-room installa- ons. Discussions took place during crystallization of *Cirolana's* engine-room layout, to determine whether automative quipment then (1966) on the market could be utilized to re- uce the amount of manual control of engine-room and lated machinery, so as to reduce the number of engineer aff below the eight proposed. No difficulties were encounter- d in arranging for full bridge control of all ship movements y main propulsion and bow propeller motors. As an 'un- anned' engine room was not contemplated as a policy, no enefit was seen in providing for starting and stopping the ain generator diesels from the bridge console, since engineers ould always be carried and would therefore be available for ese duties.

Centralized telemetering of fuel and water tank contents nd controls for their transfer were asked for in the Statement f Requirements, but motorized valves were not normally vailable for so small a vessel. Automatic alarms, centrally ited in the machinery control room, had also been a require- nent for a relatively limited number of parameters connected rimarily with the operation of the diesel generator units. To ave increased materially the number of parameters monitor- d would have required an electronic scanning system, which, y itself, did not appear to offer any possible reduction in anpower. At the time of these discussions, some delay would ave been generated whilst a design study for a computer- ontrolled auto-alarm and automatic-sequenced control ystem was undertaken. An engine-room staff reduction of hree could, perhaps, have justified the cost, but the delay was nacceptable.

Whilst *St Jasper* was 'retrofitted' with a fully-automated watchkeeper and control' system, most of the transducers were already installed during building or preparations had been made for their subsequent fitting as part of the total de- sign (Hatfield 1970, WFA 1972). In this case the effects of withdrawal of the engine-room staff to the stated desired minimum of two will be followed with interest in view of the development of the designs of two research vessels of about 250 feet LOA for Canada and Australia, both of which coun- tries have major crewing problems. The latter also has prob- lems of equipment servicing because of the great distances between her ports.

On deck, of course, winches have been remotely controlled for many years, beginning with the revolution in the Pacific tuna fishery with the introduction of the power block (Schmidt, 1959) and the multiple drum hydraulic purse seine winch (McNeely 1961, Lerch and Alverson 1961). Recent commissioning of West German stern trawlers demonstrates that remote control of large arrays of main and auxiliary winches, up to twelve storage barrels, from a single console are now commonplace. Such installations contribute to safety by reducing risks to crew members, who do not now need to handle individual wires once they have been connect- ed to the appropriate part of net or gear (Anon. 1973). On commercial vessels, deck personnel are required for gutting or fish handling, if gutting machines are provided as part of a factory installation; hence automated winches and deck gear may not be so important (from a manpower reduction point of view) as engine-room automation. The management decision to automate deck gear of research vessels should be made, therefore, on the basis of safer working conditions for crew members and greater convenience in the handling of heavy gear by a crew of an older average age than that of their commercial counterparts, a common condition on research vessels.

Powered net drums or reels for the hauling and storage of purse sines and gill nets were evolved in the early 'fifties as labour-saving devices (Schmidt 1959, Alverson 1959). Their use in stern trawlers (Anon. 1963) also permitted a minimal deck crew to operate full-size bottom, and later pelagic, trawls. However, the United Kingdom industry was slow to take advantage of the simplification of handling the long pelagic trawl by this method and no such net drums were available as standard products. Provisions were therefore made for one to be fitted on *Cirolana* in the narrow space of the 'arena' and a suitable power supply was provided. Whilst the aim in this case was more operational than one of management—a need to operate midwater and bottom trawls consecutively with a minimum of time lost in the changeover—if crewing problems are material, then a num- ber of simple deck layouts can be devised (WFA 1971, John- son 1971) utilizing net drums for both types of trawl, which, together with the handling of the otter doors in sequence, promise to effect worthwhile savings in the number of crew- men required on deck (WFA 1972).

Considering the number, complexity and cost of the winches carried on board a modern research vessel, approxi- mately 10 per cent+ of the total contract cost of the vessel, the writer is of the opinion that a deck engineer, separate from the engine-room staff, should be carried to grease, oil, main- tain and 'run' regularly all deck machinery. He would prob- able operate as a dayman in normal circumstances, but would be expected to be available at any time in emergency.

The 'FLASH' concept (Dermody *et al.* 1968), applied especially to winches, seems to have considerable value in keeping these expensive research tools operational, because of the inevitably long periods of non-use which some experi- ence. They are, therefore, far better to be stored under cover ashore than rusting in an exposed position, unused, on board for long periods.

No comment is necessary concerning the carrying of wom- en staff. This is accepted as a normal management policy, and suitable accommodation and provisions for their well-being should be included, from the outset, for the maximum num- bers likely to be carried.

(ii) *Research Areas*—Decisions to undertake research in cer- tain areas—e.g. Barents Sea or Greenland waters—cannot be avoided if those areas support the commercial fisheries which are the subject of research. The costs of providing a hull strengthened in accordance with Lloyds Ice Class recommen- dations appropriate to the vessel's duties are relatively small. Usually Ice Class II would be adequate, unless work in special- ly difficult areas, such as the Gulf of St Lawrence at the period of 'ice break-up', is envisaged. Adequate heat insulation against the low water and air temperatures together with the provision of heaters around cold water supply pipes below waterline and in winch motors used only intermittently, and good heating for accommodation are required, the latter automatically by the classification societies.

Perhaps not so obvious is the cost of deciding to operate in tropical waters. This will require Lloyd's unrestricted (Class 'B') insulation of all electrical machinery and control gear to take account of the higher ambient temperatures to be encounted during unrestricted service (Lloyd's Rules 1973). Other classification requirements will cover provision of air-conditioning and insulation, together with awnings for the protection of upper deck and superstructure accommoda- tion.

The total increase of cost for 'tropicalizing' a research ves- sel of the size of *Cirolana* could be approximately 6–8 per cent of her contract building price, i.e. her total cost excluding the cost of scientific equipment and consultancy fees, and could be more, especially if noise treatment is required for the large

air-conditioning compressor. Obviously, if the vessel is being built on a very tight budget, careful consideration should be given to the desirability of including the simple phrase 'also for use in tropical waters' without just cause.

The areas to be visited will determine the cruise length, and the total distance to be traversed during each cruise can be calculated, in order to determine the fuel bunker capacity. Much will depend upon the type of work envisaged and whether fishing or station work will represent the bulk of the time spent on the grounds. Under working, as opposed to passage, conditions fuel consumption per day may drop to some 60 per cent of passage-making consumption, or even less according to length of time on station and density of the station grid.

In calculating the endurance required for *Cirolana*, account was taken of the probability of her operating infrequently in South Atlantic waters. In order to provide a commonsense fuel capacity, it was assumed that passage-making to the most convenient port, plus a substantial bad weather allowance, should be the basis of bunker capacity. To have provided fuel for the passage, up to 21 days at cruising speed, and for the working time of up to one month on the grounds, would have required unnecessarily large tanks for her normal North Atlantic operations. It was also assumed that, on occasion, some scientific staff, for example hydrographers, might wish to take observations on the way south and to disembark and return to the laboratory to make way for a biological team. Such long-range operations would thus be the exception, not the norm, and should not be used to determine the quantity of fuel to be carried.

When considering the operation of a new research vessel the writer has attempted, as far as is practicable, to keep the cabin accommodation for both scientists and crew in the most comfortable part of the vessel. He considers that the philosophy of allocating the crew to the forward cabins 'because the crew are used to sea-going', whilst reserving the amidships accommodation for the scientists, is short-sighted and operates against the interests of the scientists. All small vessels are uncomfortable in head seas in bad weather, and loss of sleep is a by-product of the resultant motion. It is wise, therefore, to resist the temptation to utilize the most forward spaces below deck, from the collision bulkhead aft, for cabins. Whilst this is permissible under Department of Trade regulations, in the writer's experience this rule produces unnecessarily poor living standards for a vessel destined to operate predominantly in arctic waters all year round. In such a sea area it is of the utmost importance that the highest possible workable threshold of weather be maintained, and the siting of sleeping quarters as far from the 'ends' of the ship as possible will help. Although in *Cirolana* the cabin of the scientists-in-charge is some 65 feet (19.8 m) from the bow (27 per cent of the length overall), complaints of the motion experienced there in a head sea have been voiced. This would appear to be an inevitable consequence of bad weather and of ship size. The low beam length ratio which results from the desire to minimize cost by minimizing length is common to the majority of research vessels (Dermody *et al.* 1965). A 'longer' ship would have been more sea-kindly.

(b) *Maintenance*

Day-to-day maintenance of a research vessel will, of course, be undertaken by her crew. For example, the engine-room staff will be responsible for replacing items such as fuel injectors on a routine, programmed basis whilst at sea. In port, if the length of turn-round permits, valve gear etc. will be adjusted as required by the programme advised by the engine manufacturer. Major engine overhauls, however, are likely to be undertaken by the manufacturers, or their agents, on a contract basis. Thus the selection of the make of engine may be influenced by nearness of the vessel's base to such technical skills, for economy and certainty of obtaining spares. Obviously, too, 'base' should be a port where these facilities are available, together with drydocking if possible. However, fisheries research vessels can rarely be based at other than fishing ports, where the growth in size of the modern stern trawler has outstripped the old needs for which the now congested fish docks were designed (docks at Grimsby were opened in 1934). Thus the width of the 'locked' entrances to the harbours of Grimsby and Hull have for too long restricted artificially the beam of stern trawlers to around 42.5 feet. Vessels now under construction (late 1973) will not be able to enter the interior docks of either Hull or Grimsby, and at Hull the 'fish dock' is to be moved to an old dock with a wider entrance, now itself too small for modern cargo vessels. At Grimsby no dry dock now exists nor are slipping facilities available for stern trawlers, but drydocking facilities can be provided by Hull or Immingham which are reasonably convenient from the point of crewing the vessel during movement between home and refit port. Greater distances would be likely to impose undue demands on crew's time, or to require a 'runner crew' to deliver the vessel for refit and return her to her home port, an added but sometimes inescapable expense.

Just as every effort should be made at the planning stage to simplify maintenance by providing adequate space for access, so too there is need to simplify the exchange and addition of research equipment, throughout the vessel's life. The physical needs may be relatively modest and would be in the form of extensive cable ducting between laboratories and the common jig-assembled temporary fixing grids. A more delicate situation arises, however, during installation of new ship or research equipment, in that it may interfere with or disrupt the operation of another user group's gear. It follows that each new installation should be discussed at an early stage with a users' committee to ensure that any interference is minimal, that its level is known and is acceptable to the other users.

Additions which threaten amenities on board, such as new noisy equipment, should also be considered carefully and their effect minimized as far as is practicable by commonsense siting and noise-damping techniques. Criteria which may be forced upon commercial craft need not be applied to research vessels and are, in fact, invariably out of place. The primary aim of maintenance and updating of equipment is to enable research to be carried out more effectively than by using obsolescent equipment or unsuitable conditions within the vessel. Only little additional thought is required. Without it and attention to detail, the original aims, considered essential in the design phase, can only too easily be negated.

(c) *Shore facilities*

Naturally these will be dependent upon the distance between the main laboratory and the vessel's berth. The most desirable and convenient arrangement of having the vessel's permanent quay, with stores' personnel for maintenance of research equipment, transport and lifting facilities on the quay, is seldom possible in congested fishing ports (NERC 1973). Negotiations with the quay owners should ensure that, at least, an electricity supply and telephone can be provided. The former will rarely be capable of supplying all domestic services for the vessel, i.e. it cannot be expected to take the place of the harbour alternator. However, a cable of sufficient capacity, (*Cirolana* uses mining cable for a maximum load of 100 kVA) can be related to selected essential harbour services, e.g. background and selected regional heating, ventilation, lighting, winch motor heaters, stabilized laboratory supply and a low level of galley supply, i.e. no cooking should be expected but hot drinks should be available.

Two consequences stem from the ability to connect the ves- l to the town 'mains' supply, which will, of course, require be of 3-phase: (a) The provision of light and power to all oratories enables scientific equipment to be installed and sted without the presence of engine-room staff to run up the rbour alternator. Tests of new equipment can thus be made the scientists' convenience. (b) The AC distribution switch- ar must be designed to Lloyd's requirements, and also to ose of the appropriate electricity generating agency. In the nited Kingdom the Central Electricity Generating Board gulations do not permit an earthed supply, i.e. a 3-phase and eutral supply, to be fed into the normal ship's system, which as a separate earthed neutral. The ship's 'earth' therefore ust be provided with a removable link, interlocked, and thus perated automatically when connection is made to the shore pply.

The remaining shore facilities should be considered at the me time as the ship design and together should constitute e most suitable overall facilities for the research to be under- ken. Lifting of heavy gear and stores is required for each ruise. This may be carried out by the vessel's own cranes or lewing derricks, by shore-based dock-side cranes, or by obile units hired for each occasion. Similar lifting gear is eeded at the stores complex. Frequently, if the laboratory nd store are not even in the same town, a single storeman nay be the only person available to take delivery of and store eavy gear during the periods when the research vessel is at ea. The store must therefore be provided with mechanical ids to enable one man to undertake this heavy work, unless rane hire promises to be available on demand.

Rewind winches for exchange of wires and cables on the hip's winches will be invaluable and should, of course, be rovided with a tensioning device which will allow the cable o be put back on to the shipboard winches ready for use, i.e. without their requiring to be streamed at sea before use. All hipyards, repair yards and commercial trawler port installa- tions would benefit by such rewind facilities for the handling of the 1,200 and 1,500 fathom (2,200–2,750 m) trawl warps carried currently by the normal UK freezer trawler, but no port is so provided as yet. Damage to warps during the tradi- tional method of providing tension by introducing friction around several quay bollards is considerable. Manpower and handling time for the frequent warp-marking needs could be reduced and the whole operation simplified by the use of such a rewind winch unit. It would also avoid the introduction of innumerable 'turns' into the warp, caused by the common practice of taking the warp from the coil when on its side on the quay.

Space for spreading nets for repair or rigging may well be desirable if space on board the vessel is unduly restricted.

The decision to include any laboratory accommodation at the base port will also depend upon the distance of the main laboratory from the stores complex and the degree of auton- omy required. Once again, a 'systems' approach is required to provide commonsense convenience for operating a research tool.

Owner's trials

Finally, the new vessel should not be considered ready for service immediately following acceptance trials. All combinations of research and ship equipment must be tested to the satisfaction of each specialist user group. Each group should be responsible for ensuring not only that the vessel contains what they have specified but also that the equipment installed operates as they require.

These detailed trials should be undertaken systematically and completed before the end of the 'Guarantee Period', usually six months unless otherwise agreed with the builder, as a matter of straightforward economic management. After that period the cost of rectifying all defects and deficiencies will fall to the operating body. Agreement on responsibility for any shortcomings must also be determined before the guarantee lapses. The temptation to put the vessel into service at once is strong and, in view of the apparent inevitability of late deliveries, understandable. However, the long-term benefits of thorough and critical testing before cruise programmes are initiated cannot, in the author's experience, be overstressed.

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The reference to proprietary products in this report should not be construed as an official endorsement of those products, nor is any criticism implied of similar products which are not mentioned.

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Appendix 1
RV *Cirolana*
General technical data

1 SHIP DIMENSIONS AND DATA

Length overall 238.75 feet (72.8 m).
Length between perpendiculars 205 feet (62.5 m).
Beam (moulded) 46.0 feet (14.02 m).
Beam overall 46.125 feet (14.08 m).
Mean draft, i.e. amidships, 16.5 feet (5.03 m).
Loaded free-running draft aft 17.25 feet (5.26 m), i.e. 1.5 feet (0.49 m) trim.
Maximum trim achievable 5 feet (1.52 m).
Normal maximum draft (aft) for fishing 18.25 feet (5.55 m)
Maximum displacement, i.e. departure condition, 2 382 tons.
Maximum speed (trials) 15 knots. Normal cruising speed 14.25 knots.
Gross Register Tonnage 1 593.79 tons.
Net Register Tonnage 378.85 tons.
Diesel oil bunker capacity 344 tons (including daily service tanks).
Range at speed of 14 knots=10 000 nautical miles.
Freshwater tank capacity 103 tons (includes 'potabie' water and fresh water in after trimming tanks for maximum endurance).

Two evaporators in engine room (Figures 4 and 5) can each provide 5 tons fresh water per day when on passage at cruising speed, if necessry, to augment water supplies. When on fishing grounds or during low power, e.g. station-working, insufficient cooling water is delivered to the evaporators for economci freshwater production. An automatic sewage treatment plant is also fitted on the port side of the engine room (Figures 4 and 5).

Stabilizer tank has a loading at departure of 16 tons, with water depth of 1.5 feet (45 cm) and with vessel's angle of heel zero. This loading was amended, after Ship Division's (NPL) full-scale forced rolling trials—achieved by rhythmic reversal of helm from 'hard over' to 'hard over'—from the original figure of 20 tons, derived from model experiments (Trout 1974).

2 COMPLEMENT

Maximum scientific staff=10 (9 plus spare cabin labelled Wireless Officer).
Ship's Officers and Crew=30.
Captain.
First Officer.
Fishing Skipper.
Watchkeepers { Mate and 3 Deckhands / Bosun and 3 Deckhands / Third Hand and 3 Deckhands }
Wireless Officer.
Electrical Officer.
Catering/Cleaning staff { Chief Steward / Cook / Assistant Cook / 3 Stewards }
Chief Engineer.
Watchkeepers { Second Engineer and Oiler / Third Engineer and Oiler / Fourth Engineer and Oiler }
(Deck Engineer/Donkeyman, not carried to date.)

3 MACHINERY

Propulsion machinery Diesel-electric. All electrical machines by Laurence Scott & Electromotors, with Lloyd's Class 'B' (Universal) insulation for unrestricted service.

Diesel generator sets 3×1 100 bhp 6 cylinder W. H. Allen Sons and Company Limited diesel engines, type PBC-S37E running at 500 rev/min and driving 3×700 kW DC generators in a 'constant current loop'. Loop current maintained at 1 300 amperes. Loop circuit includes generators, propulsion motor, bow propeller motor and main trawl winch motor. (Wing generator sets also drive tandem alternators, see Figure 5.)

Propulsion motor 2 200 shaft hp at 180 rev/min is composed of two tandem armatures of 1 100 hp, each capable of being isolated or removed, if damaged, to permit vessel to operate at half power, i.e. up to 12–12.5 knots (speed/power curve Figure 15).

Infinitely variable speed control of motor, between 5 and 186 rev/min (normal maximum), available from bridge or machinery control room. Bridge control is normally employed.

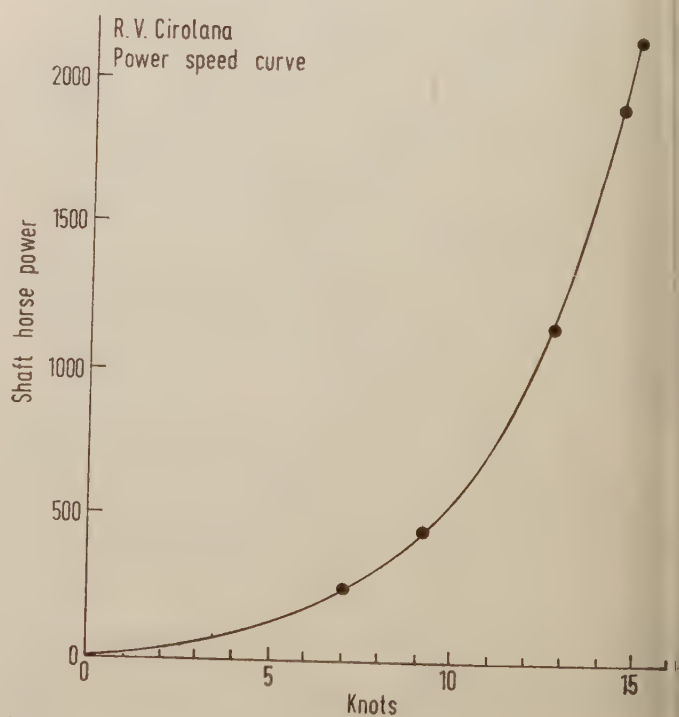

FIG. 15.

DC power availability and performance Examples:

(i) 1 *generator set*, i.e. 700 kW with tandem alternator of 400 kW.
  (a) 700 kW DC to propulsion motor (no AC)= 11.8 knots;
  (b) 300 kW AC load, 400 kW to propulsion motor=9 knots.
(ii) 2 *generators*, i.e. 2+700 kW DC plus 1 or 2 alternators.
  (a) 1 400 kW DC to propulsion motor (no AC)= 13.8 knots;
  (b) 400 kW AC load, 1 000 kW DC to propulsion motor =13 knots.
(iii) 3 *generators*, i.e. 3×700 kW DC with two wing alternators sharing AC load: wing DC generators at settings below 700 kW.

Power/speed: electrical input/mechanical output from trials data:
223 kW (242 shp) 7 knots
373 kW (452 shp) 9.22 knots
945 kW (1 150 shp) 12.72 knots
1 553 kW (1 905 shp) 14.63 knots
1 735 kW (2 160 shp) 15 knots.

) *Bollard pull*
2 generators, 19.9 tons at 128 rev/min and 1 085 shp.
3 generators, 26.9 tons at 156 rev/min and 1 760 shp.

) *Bow propeller* (retractable and rotatable)
260 kW DC, 350 hp electric motor. 4-bladed propeller 52 inches (1.32 m) diameter. Ship speed on bow propeller alone 6 knots plus in calm weather.

AC SUPPLIES

Four sources of AC are provided, viz from
(a) tandem alternators on the outer (P and S) two main diesel generators—the 'wing' generators;
(b) a harbour generator for use when the vessel is in a 'foreign' port, i.e. not at Grimsby, and when the main generators are shut down;
(c) the town (CEGB) mains supply when the vessel is in the port of Grimsby;
(d) a stabilized single-phase supply to the Plotting Room, to all laboratories, and to selected ship and navigational instruments, and available at all times.

The AC power supplies are as follows:

a) 2×500 *kVA*, 415 *volt*, 50 *Hz*, 3-*phase alternators* running t 500 rev/min fed to a common busbar, which can be 'split' nto two by an isolating switch, with approximately equal oadings of ± 200 kW. No paralleling control gear is necesary and approximately 100 per cent standby capacity is proided for future demands and developments. Alternatively, ne wing generator set can provide all AC ship/research upplies, for example when the centre and one wing diesel enerator are operating.

b) *Paxman* 8 *RPHCZ diesel* driving a 375 kVA, 415 volt, 50 Hz, 3-phase alternator at 1 500 rev/min to provide selected ervices, heating, lighting and emergency supplies and (d) the tabilized laboratory supply.

c) *Shore supply* of 100 kVA via 5-pin, 100 ampere flameproof socket connected to a gate-end box on the quay by means of trailing cable. Connection can be made, to appropriate coupling/switch fuse, from either side of the vessel when berthed. Used for laboratory supply (d) and selected heating/lighting.

(d) *Laboratory supply* (stabilized for voltage and frequency) of 50 kVA, 240 volt, single-phase 50 Hz, provided by using two motor generator sets (under the main engine acoustic hood, Figures 5 and 6). A vertical MG set of a 75 hp, 415 volt, 3-phase Trislot (AC) motor drives a 50 kW DC generator, which in turn drives a 60 hp DC motor coupled to an Altomag single-phase AC generator. The latter's speed control is by static components in the switchboard which are not subject to those load and frequency variations occurring in the diesel-driven AC power supply as a result of changing sea/course/operational conditions.

The frequency of the alternating current is regulated by a combination of electro-mechanical elements—by comparison of the output of a master crystal chronometer installed in the Plotting Room, and the ZITE (Zero Integral Time Error) equipment manufactured by Laurence Scott & Electromotors Limited—to within ± 1 per cent and voltage regulation to within ± 2 per cent.

Response time for restoration of frequency to within 1 per cent, and to within 3 per cent of voltage, for 100 per cent load changes, is 1 second.

5 WINCHES

(i) *Main trawl winch* by C. D. Holmes

Construction Four drums, two main warps and two auxiliary bridle drums and double score whipping drums.

Capacity 1 200 fm (2 200 m), $3\frac{1}{4}$ inch circ. (nominal 1 inch or 26 mm diameter) warp in 17 layers, spooled by LeBus grooving on a 'split sleeve' (Figure 14). (Hydraulic mechanical spooling fitted but not used.) Auxiliary drums for 35 fm (69 m) messenger wire of $3\frac{1}{4}$ inch circ. (nominal 1 inch or 26 mm diameter) plus 2×75 fm $2\frac{7}{8}$ inch (23 mm diameter) bridles for use with pelagic trawls.

Disc brakes on warp drums. Band brakes on auxiliary drums. Hand-operated clutches.

Power 297 kW (400 hp) DC deck watertight motor in constant current loop. Motor speed 800 rev/min: speed control infinitely variable. Bevel gear drive to after side of winch gives 25:1 reduction and permits regenerative braking. Motor has magnetic disc brake. Anti-condensation heating coils operate when power is switched from motor.

Duty 24 tons at minimum radius, at 220 feet/min (67 m);
15 tons at mean radius, at 350 feet/min (107 m);
11 tons at maximum radius, at 470 feet/min (143 m).

Average speed for deep trawling, i.e. with 1 200 fm (2 200 m) warp out, 300 feet/min (91 m) approximately (Bridger, pers. comm.).

(ii) *Net drum winch* (Stothert & Pitt) (Plate 5)

Drive Electro-hydraulic direct drive by two Haaglund slow speed radial-piston hydraulic motors, type 6170. Laurence Scott & Electromotors 75 kW (100 hp), 415 volts, 3-phase, 50 Hz motor drives Linde variable displacement hydraulic pump. Two-speed valve permits drum speed to be doubled with reduced torque.

Capacity of net drum 4.5 m^3, i.e. to take Engel 1 600/572 herring/cod pelagic trawl. Bridle drum capacities suitable for 35 fm (69 m), $3\frac{1}{4}$ inch circ. (1 inch nominal, 26 mm diameter) messenger plus 2×75 fm (137 m), $2\frac{7}{8}$ inch circ. (23 mm diameter) bridles.

Net flange diameter 2.165 m; 1.50 m between flanges. Barrel diameter 0.900 m. Bridle flanges 1.700 m diameter.

Pull and duty Bridle speed on half displacement 148 feet/min (45 m) at 4 tons. Cod-end speed at full displacement 111 feet/min (34 m) at 7 tons. Approximate time for recovery of Engel trawl $3\frac{1}{2}$ minutes.

(iii) *Auxiliary after deck winches* (Laurence Scott & Electromotors Scott 'Corrector' type 3 ton capacity standard cargo winches)

Two single fixed drum and whipping drum winches, i.e. not declutchable—an 'economy' measure—one sited each side of ramp on fishing deck for all auxiliary lifting duties, otter doors, cod-end emptying and mooring duties.

Motor 23 kW (31 hp), 415 volt, 3-phase, 50 Hz at 1 450 rev/min.

Duties: 3-step operating speeds;
3 tons load at 80 feet/min (24 m);
$1\frac{1}{2}$ tons load at 150 feet/min (49 m);
light hook speed, i.e. 'no load', 320 feet/min (105 m).

(iv) '*Netzsonde*' *winch*
Standard Elac KAW3C. Single barrel.
Motor 7.5. kW, 3-phase AC at 1 450 rev/min.
Cable length 2 600 m, 12–12.5 mm diameter.
Breaking straing 1 400 kg (=3 000 lb).
Standard automatic torque control.
Average hauling speed approximately 2 m/second.
Controls on bridge, at after winch console.

(v) *Slip ring research winches*

The three winches, main cable, auxiliary cable and hydrographic winches are of similar basic two-drum design (Plate 5

	Main cable	Auxiliary cable	Hydrographic
MG sets	50 hp AC motor 34 kW generator	25 hp 16.5 kW	25 hp 16.5 kW
Winch motor	40 hp	19 hp	11 hp
Drum capacity	1 250 fm, ½ inch dia. cable (2 280 m of 13 mm dia.)	3 000 m, 6 mm cable, smaller drum 750 fm ½ inch (13 mm) dia. cable	3 500 m, 4 mm cable or hydrographic wire
Drum diameter	20 inches (50 cm)	20 inches (50 cm)	18 inches (46 cm)
Rate of haul	300 feet/min at mean dia. (92 m/min)	300 feet/min at mean dia. (92 m/min)	350 feet/min at mean dia. (106 m/min)
Maximum end load	1 ton (1 000 kg)	750 lb (340 kg)	400 lb (180 kg)
Slip rings	24 way on each drum	24 way on larger drum, 16 way on smaller drum	16 way on after drum only

Barrel entry cable-gland and spooling on each winch can be adjusted to accept a range of cable/wire diameters

and Figure 3), but with different powers and capacities to fulfil the stated requirements.

Each is driven by a deck watertight DC motor controlled on the Ward-Leonard principle with DC current provided by a vertical motor generator set on the Machinery Control Room flat (Figures 4 and 5), after starboard side.

Control gear cubicles for each of the three winches are also in the Machinery Control Room flat (starboard side).

(vi) *Deep anchoring winch* (Clark Chapman & John Thompson Ltd)

A single storage drum for 500 fm (965 m), 3½ inches circumference wire rope (1⅛ inches or 29 mm diameter) incorporated into an otherwise standard anchor windlass and mooring winch.

Duty of 20 hp electric motor at 1 440 rev/min at 20 inches diameter (0.57 m) barrel;

3 tons at 76 feet/min (23 m) minimum radius;
2.25 tons at 104 feet/min (32 m) mean radius;
1.75 tons at 132 feet/min (40 m) maximum radius.

If operated at 20 hp, but at half speed, line pull is doubled. Used normally, i.e. as anchor capstan, will recover simultaneously both anchors weighing 3 000 lb each (total=2 720 kg) at 30 feet/min (9 m/min) from 45 fm (82 m).

(vii) *Portable winches* can be carried as required—watertight plug sockets available on laboratory bulkheads on main deck level.

6 EQUIPMENT AND FACILITIES

In order to achieve maximum flexibility in usage and economy in outfitting, most research equipment is installed on board temporarily for a specific cruise and is removed after use. Some items, however, may be considered to be installed permanently on board, and additions and modifications to these are made as demands and design change and the potential of the equipment is developed. For example, the computer/data-logger complex developed from the spare capacity of the small Hewlett-Packard computer, installed originally as part of the Satellite Navigation System. Addition of a second computer permits the complex to be operated as a 'Real Time Executive System' (RTE), capable of running more than one program on a 'priority interrupt' basis—the data logging having top priority. It is planned to handle biological, oceanographic and acoustic survey data.

The total navigation/computer/data logger installation is planned to include the following items, which are concentrated in the Plotting Room:

Magnavox Mk 902–3 satellite signal receiver.
Teleprinter.
4 visual display monitors (Bridge, Main, Clean Biol. and Hydro. Chem. Lab.).
Speed and heading interfacing for Colnbrook electromagnetic log, distance run integrator, Arma Brown gyro compass.

2 Hewlett-Packard 2100A computers, each with additional 8K memory.
Disc store unit.
LX 180 line printer (console printer).
Paper tape punch.
Paper tape reader.
Drum plotter.

Cable ducts connect the Plotting Room to all other laboratories, the engine room, bridge and overside monitoring equipment, and simplify connection of equipment to the data logger complex.

Acoustic survey instruments are as follows, (a) in Plotting Room (b) on bridge.

(a) Kelvin Hughes Humber gear.
Marconi Fishgraph Mk II.
Simrad model EH2
100 kHz MAFF A100 series (treated as 'temporarily installed' equipment).

(b) Elac 'Super Lodar' sonar.
Kelvin Hughes MS 44.
Kelvin Hughes MS 29 (for headline transducers).

Equipment additional to the Satellite Navigation System includes:

Arma Brown gyro compass (with repeater compass in Plotting Room and on Bridge top).
Auto-Pilot.
Kelvin Hughes 21/16P 19/9C interswitched radar, with timer and a 19/12 slave display (Plotting Room).
Decca Loran C model DL21.
Decca Navigator.
2 Decca Track Plotters and Mark 12 receivers (1 in Plotting Room).
Sal log 24.
Kelvin Hughes MS 44 echo-sounder.
Kelvin Hughes MS 29 headline recorder.
Elac 'Super Lodar' sonar.
Course recorder.

Radio equipment

(a) *Radio Room:* call sign GNAM.
Marconi 'Atalanta' GP receiver.
'Crusader' SSB transmitter with 9 additional crystal frequencies.
'R 408' SSB receiver.
'Salvor II' W/T emergency transmitter (battery operated).
'Argonaut' VHF—with additional Bridge control unit.

Bridge

Marconi 'Harbafone 20' 6-channel VHF.
Marconi 'Kestrall III' R/T (2 Mc/s) with additional 3 crystal frequencies.
Marconi 'Lodestar II' automatic gyrostabilized DF.
Marconi 'Warden' receiver (for continuous distress frequency watch).
Marconi Mufax Forecaster I with 12 crystal controlled frequencies.

Weather station on bridge

Mufax Facsimile recorder.
Anemometer—direction and speed.
Recording barograph.
Distant-reading sea surface thermograph.
Stevenson's screens (P and S).
Solar radiation recorder.

ternal communication

Marconi Elletra system for laboratories/deck working positions (i.e. winch control positions).
16 point TMC Flexicom system for Bridge, Chief Scientist, Captain, Chief Engineer, Wardroom, Galley and 6 Scientists' cabins.

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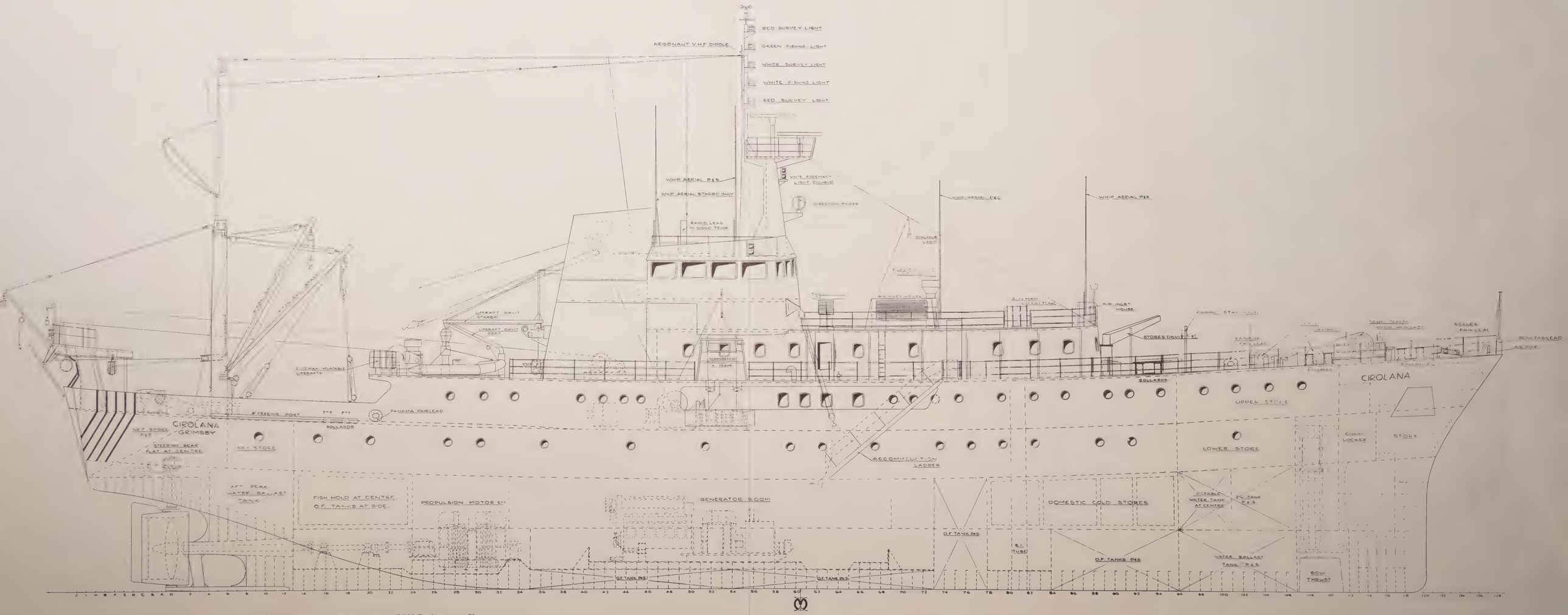


FIG. 2 General arrangement drawing of RV *Cirolana* in profile. Retractable bow thruster shown housed, with propeller forward (see also Figure 11).

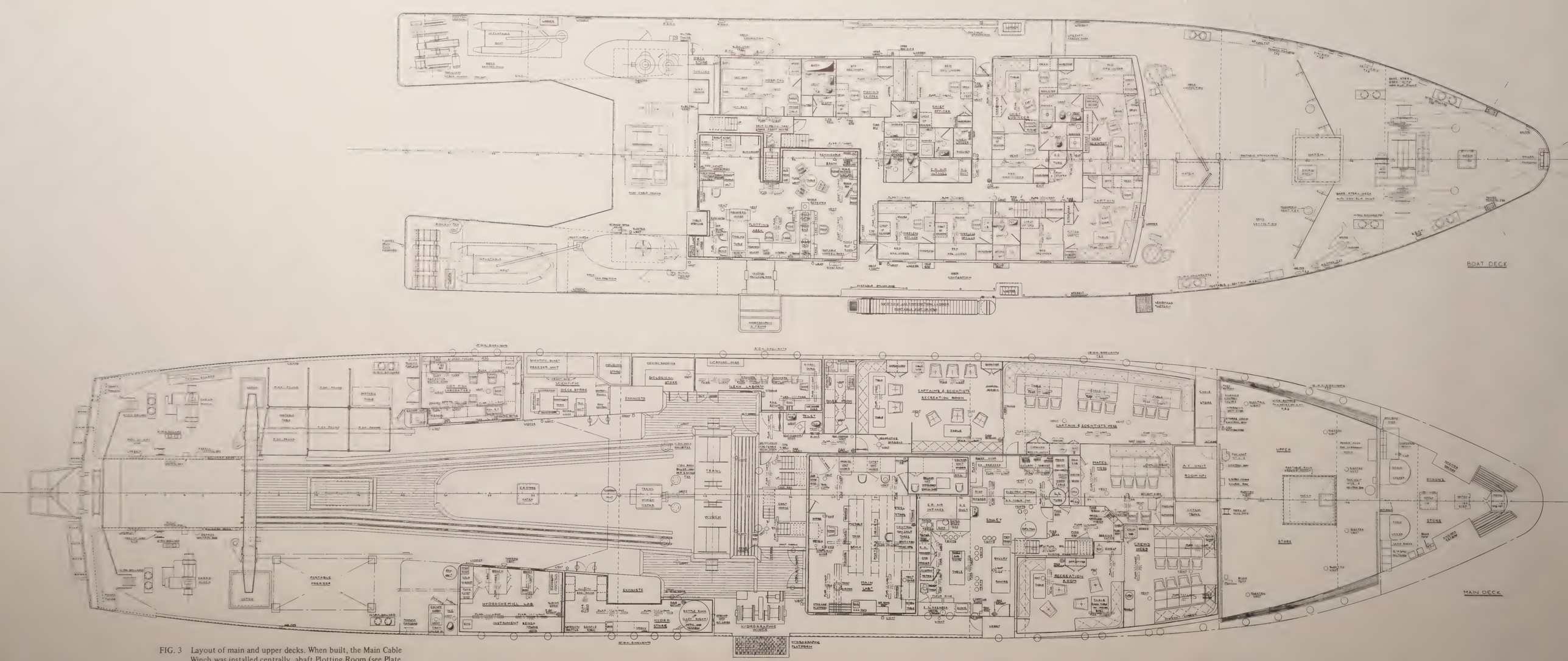


FIG. 3 Layout of main and upper decks. When built, the Main Cable Winch was installed centrally, abaft Plotting Room (see Plate 5 of Net Drum and Main Cable Winches).

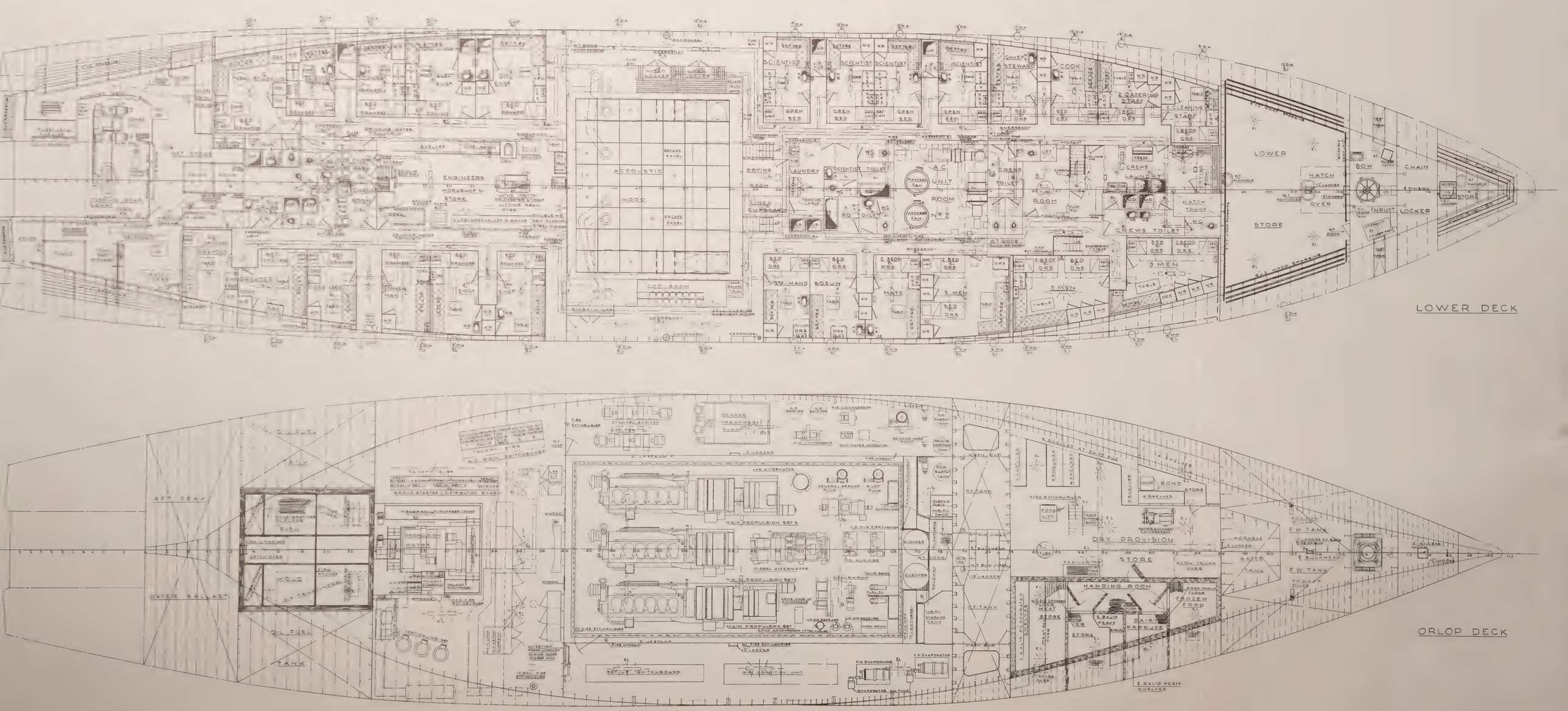
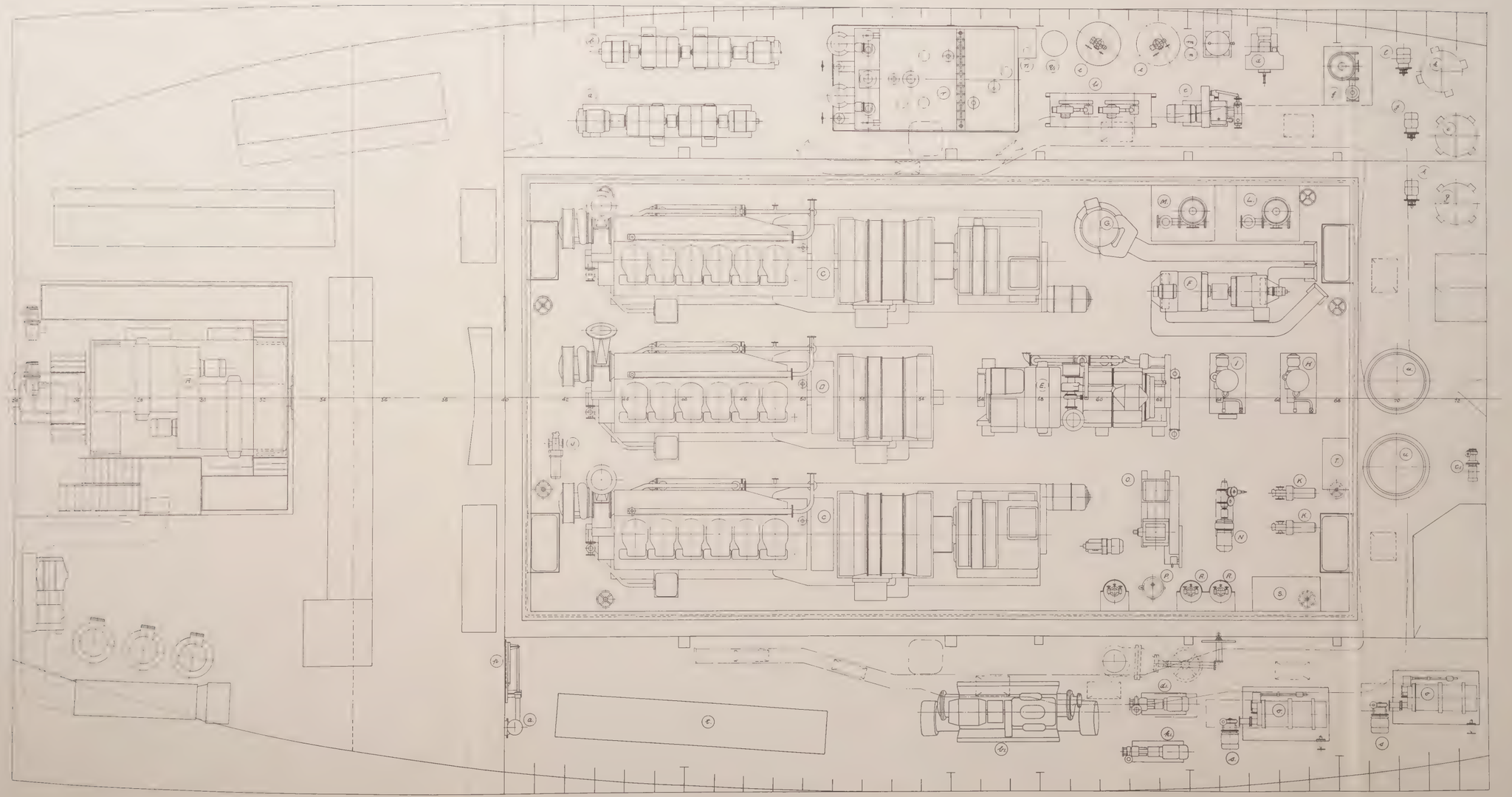


FIG 4. Layout of lower (accommodation) deck and orlop deck. Watertight doors in alley ways.



T	SEPARATE TANK FOR SERVICE PLANT			GRIMSDALE
S	AIR RECEIVER (FULL PRESS)	8.0 CU. FT.	ONE	
R	PORT AIR INLET BOXES		2	FERGUSON BROS.
Q	STRAINER L.O. TANK		ONE	FERGUSON BROS.
P	AIR ALTERNATOR EXH. SILENCER		ONE	HOWDEN
O	ARMY GENERATOR EXH. SILENCER		3	ALLPASSES
N	SERVICE PLANT AIR COMPRESSORS		ONE	FORRESTS (GREENOCK)
M	AIR CONDITIONING CHILLED WATER PUMP		ONE	WESTINGHOUSE-SIMPLEX
L	MAINS S.W. CIRC. PUMP		ONE	DAVEY PAXMAN
K	CARGO HOLD CONDENSING UNIT		2	L. STERNE
J	HYDRAULIC MAIN MOTOR SET	100 GALLONS	1	LAWSON SCOTT
H	HYDRAULIC WINCH MOTOR SET	100 GALLONS	1	LAWSON SCOTT
G	AUX. CRANE WINCH MOTOR SET	100 GALLONS	1	LAWSON SCOTT
F	MAIN CABLE WINCH MOTOR SET	100 GALLONS	1	LAWSON SCOTT
E	AIR CONDITIONING UNIT S.W.C. PUMP		ONE	WESTINGHOUSE-SIMPLEX
D	FRESH WATER TRANSFER PUMP		ONE	DAVEY PAXMAN
C	AIR CONDITIONING UNIT			
B	DIESEL DRIVEN AIR COMPRESSOR FUEL TANK	9 GALLONS	ONE	HORSTMANN
A	SALT BALLAST TANK	500 GALLONS	ONE	FERGUSON BROS.
	FRESH WATER TANK	500 GALLONS	ONE	FERGUSON BROS.
	MAIN & AUX. ENGINE F.W. HEADER TANK	70 GALLONS	ONE	FERGUSON BROS.
	PORT EXHAUST VENT SILENCER		2	HOWDEN & HARRIMAN
	PORT EXHAUST VENT FAN		2	HOWDEN & HARRIMAN
	A.C.H. AIR INLET SILENCER		2	HOWDEN & HARRIMAN
	SEPTIC SANITATION PLANT		ONE	L.C.C. (SEPTIC TANK) & BOOTH & KAYE (SPRINKLING FILTER)
	EVAPORATOR S.W. PUMP		2	WEIR'S CLYDE & BOOTH
	SEWAGE TREATMENT PLANT	240 CU.FT.	ONE	GRIMSDALE
	HYDRAULIC PUMP FOR HYD. SLIDING DOOR	700 P.S.I.	ONE	VICKERS ARMSTRONG
	A.C.H. SLIDING DOOR	5'-0" x 6'-0"	ONE	VICKERS ARMSTRONG
	A.C.H. EVAPORATORS	3 TONS/DAY	2	HOWDEN CLYDE & BOOTH
	SWL BLGE. PUMP	3.7 T.H.	ONE	FARMER LTD.
	SWL WATER SEPARATOR	3 TONS/DAY	ONE	FARMER LTD.
	PNEUMATIC S.W. PUMP	2000 H.P.S.I.	ONE	DRYSDALE
	PNEUMATIC S.W. SUPPLY TANK	8 CUBIC FEET	ONE	DRYSDALE
	PNEUMATIC DRINKING WATER PUMP	2000 H.P.S.I.	ONE	DRYSDALE
	PNEUMATIC DRINKING WATER SUPPLY TANK	8 CUBIC FEET	ONE	DRYSDALE
	PNEUMATIC D.F.W. PUMP	2000 H.P.S.I.	ONE	DRYSDALE
	PNEUMATIC D.F.W. SUPPLY TANK	2 CUBIC FEET	ONE	DRYSDALE
	BALLAST PUMP	SEE OUTSIDE PUMP	ONE	DRYSDALE
	AIR RECEIVER (STARTING)	23 CU. FT.	2	(1 MAIN ENGINE & 1 A.E.)
	DIESEL DRIVEN AIR COMPRESSOR	50 CU.FT. @ 3000 P.S.I.	ONE	HORSTMANN
	MOTOR DRIVEN AIR COMPRESSOR	140 CU.FT. @ 3000 P.S.I.	ONE	HORSTMANN
	STAND BY EXCITER — D.C. PROPULSION MOTOR	35KW @ 220V.	1	LAWSON SCOTT
	STAND BY EXCITER — D.C. PROPULSION GENERATOR	35KW @ 220V.	ONE	A.C. ELECTROMOTORS
	STAND BY EXCITER — D.C. WINCH MOTOR	35KW @ 220V.		
	STAND BY EXCITER — D.C. PROPULSION MOTOR	35KW @ 220V.	1	LAWSON SCOTT
	STAND BY EXCITER — D.C. PROPULSION GENERATOR	35KW @ 220V.	ONE	A.C. ELECTROMOTORS
	STAND BY EXCITER — D.C. TRANSHIPPING MOTOR	35KW @ 220V.		
	CARR'S MARK "UP" AIR COMPRESSOR			
	MAIN D.C. GENERATOR — D. CRANE TRUCK	100 GALLONS	ONE	FERGUSON BROS.
	THRUSTER & PROPULSION GENERATOR — 2 SETS	100 GALLONS	2	FERGUSON BROS.
	CARGO ARRANGEMENT BLOCK		ONE	FERGUSON BROS.
	WINCH DRIVEN		ONE	FERGUSON BROS.
	DAVIT DRIVEN		ONE	FERGUSON BROS.
	A.C. AIR RECEIVER (C.P. No 2)	3 CU.FT.	2	DENNY ELECT. SERVICE
	A.C. AIR RECEIVER (C.P. No 1)	3 CU.FT.	ONE	HOWDEN ELECT. SERVICE
	CARGO AIR COMPRESSOR AFTER COOLER		ONE	HOWDEN (SHEARER)
	CARGO GROUP AIR COMPRESSOR		ONE	FORRESTS (GREENOCK)
	CLEAN & BILGE PUMP	10 TONS/HOUR @ 50 P.S.I.	ONE	SHEPHERD & PAXMAN
	GENERAL SERVICE PUMP	10 TONS/HOUR @ 50 P.S.I.	ONE	DRYSDALE
	BILGE PUMP	10 TONS/HOUR @ 50 P.S.I.	ONE	DRYSDALE
	FUEL OIL TRANSFER PUMP	3.7 T.H.	2	DRYSDALE
	L.O. STANDBY & TRANSFER PUMP	360 G.P.H.	ONE	DRYSDALE
	FUEL OIL PURIFIER	1.67 T.H.	ONE	ALFA-LAVAL
	L.O. PURIFIER	1.66 T.H.	ONE	ALFA-LAVAL
	LABORATORY GENERATION (VIBRATION)	50 KW	ONE	A.C. ELECTROMOTORS
	LABORATORY ALTERNATOR	50 KW	ONE	A.C. ELECTROMOTORS
E	ALTERNATOR — AUXILIARY DIESEL ENGINE SET	3 PHASE 50 CYCLE 1500 RPM @ 1500	3	L.E.B.E.C. / L.E.B.E.
	DIESEL ENGINE SET	MAKER'S NAME 1500 RPM @ 1500	3	H.W.M. (LEN)
D	D.C. GENERATOR — MAIN PROPULSION SET	350 KW 600 V. 583 AMPS 1500 RPM	3	L.E.B.E. / L.E.B.E.
	DIESEL ENGINE	MAKER'S NAME 1500 RPM @ 1500	3	H.W.M.
C	ALTERNATOR — MAIN PROPULSION SET	350 KW @ 1500 RPM	1	L.E.B.E.
	D.C. GENERATOR — PROPULSION SET	350 KW 600 V. 583 AMPS 1500 RPM	1	L.E.B.E. / L.E.B.E.
	DIESEL ENGINE — SET	1500 B.H.P. @ 1500 R.P.M.	1	H.W.M.
B	PROPULSION MOTOR COOLING PUMP	1500 GALLONS @ 50 P.S.I.	2	SHEPHERD & PAXMAN
A	PROPULSION MOTOR	350 KW 600 V. 583 AMPS 1500 RPM	1	LAWSON SCOTT A.C. ELECTROMOTORS
MARK	DESCRIPTION	SIZE	No.	SUPPLIER

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FIG. 5 Plan of engine room showing extent of hood.

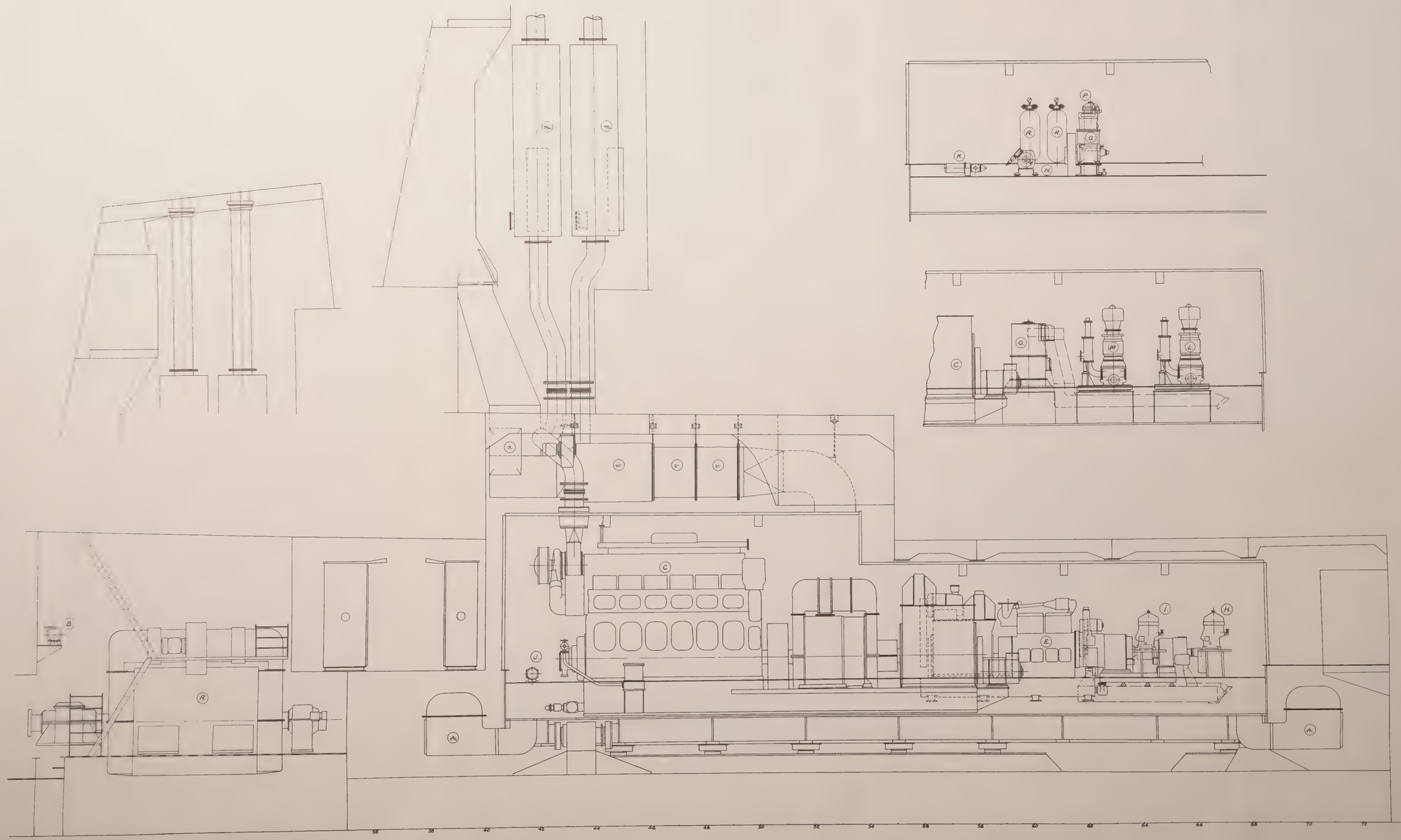

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FIG. 6 Longitudinal section of engine room showing hood and raft support

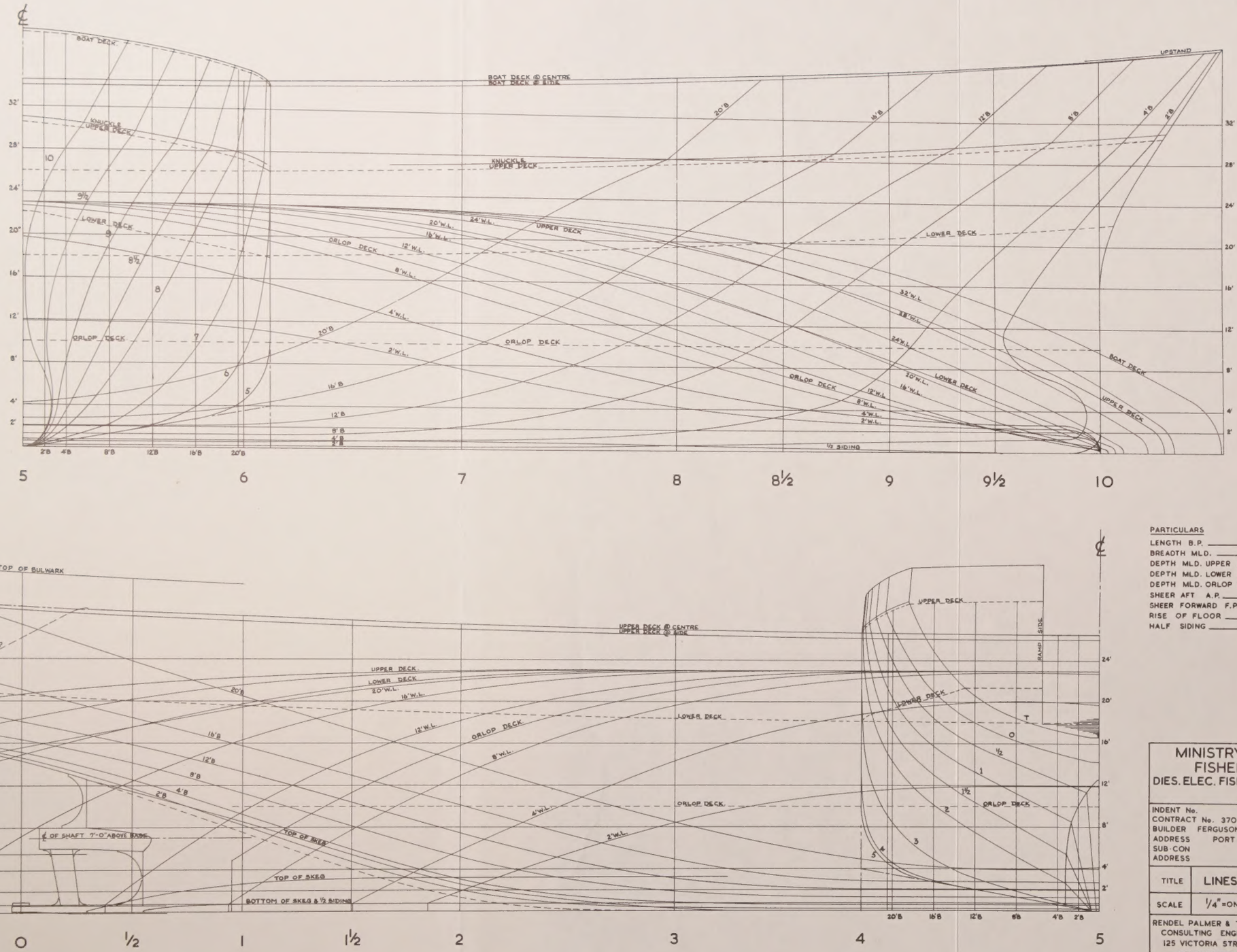

FIG. 11 The lines represent a hull with the following design characteristics: LBP=205.0 feet (62.5 m); beam moulded 46.0 feet (14.02 m); depth moulded=26.0 feet (7.93 m); C_b=0.520; C_p=0.601; LCB (aft)=5.57 feet (1.7 m aft); ½ angle of entrance=14.5°; length of entrance=110.7 feet (33.77 m); length of run=94.3 feet (28.77 m).

PARTICULARS

LENGTH B.P.	205'– 0"
BREADTH MLD.	46'– 0"
DEPTH MLD. UPPER DECK	26'– 0"
DEPTH MLD. LOWER DECK	18'– 0"
DEPTH MLD. ORLOP DECK NO SHEER	10'– 0"
SHEER AFT A.P.	2'– 6"
SHEER FORWARD F.P.	4'– 0"
RISE OF FLOOR	4'– 0"
HALF SIDING	9 INCHES

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TITLE	LINES PLAN
SCALE	1/4"=ONE FOOT
BUILDERS DRG No. D.1	

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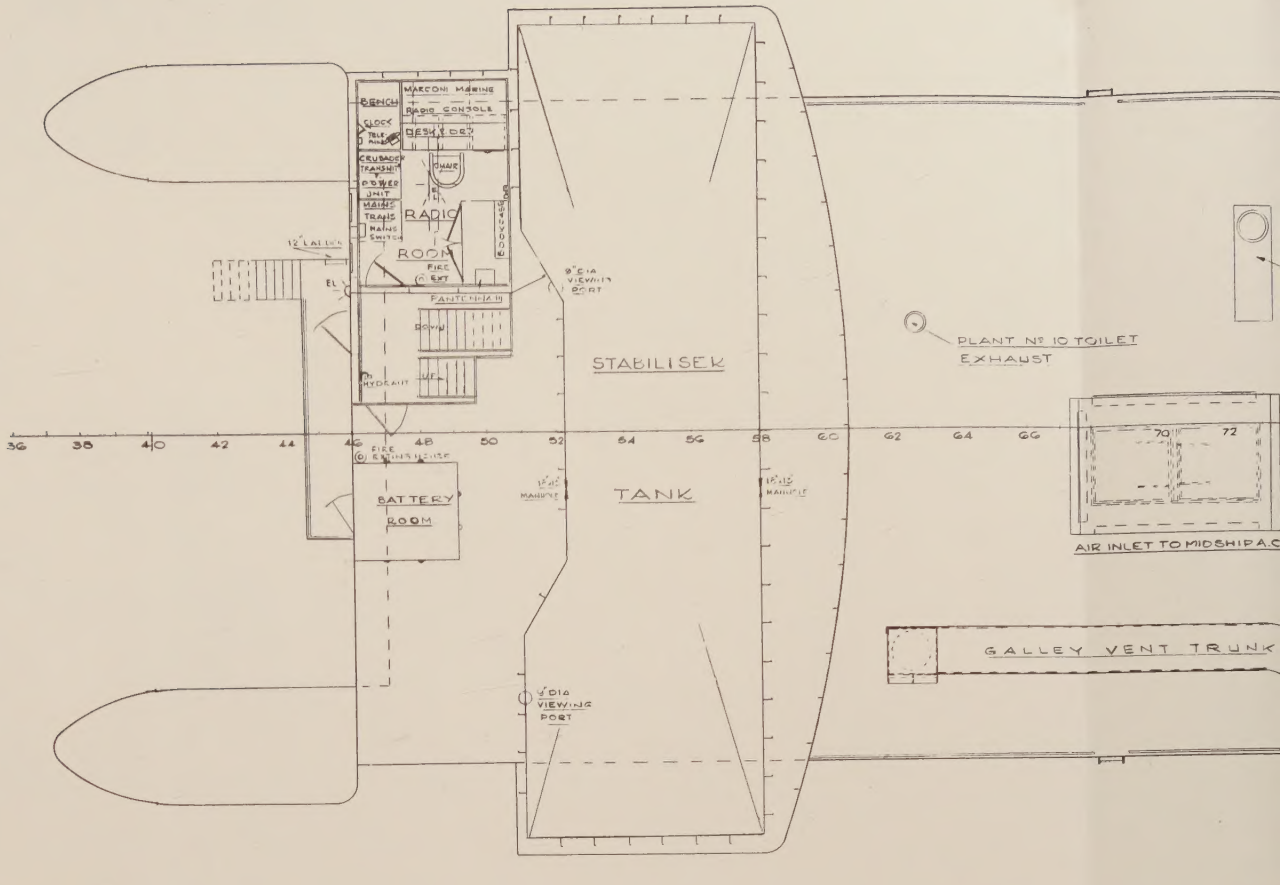
BENCH
MARCONI MARINE
RADIO CONSOLE
CLOCK
DESK
CRUSADER
TRANSMIT
POWER
UNIT
MAINS
TRANS
MAINS SWITCH
SHAVER
RADIO
ROOM
FIRE
EXT
FANTENNA IN
DOWN
UP
HYDRANT
12" LATCH
EL
9" DIA VIEWING PORT
STABILISER
PLANT Nº 10 TOILET EXHAUST
36
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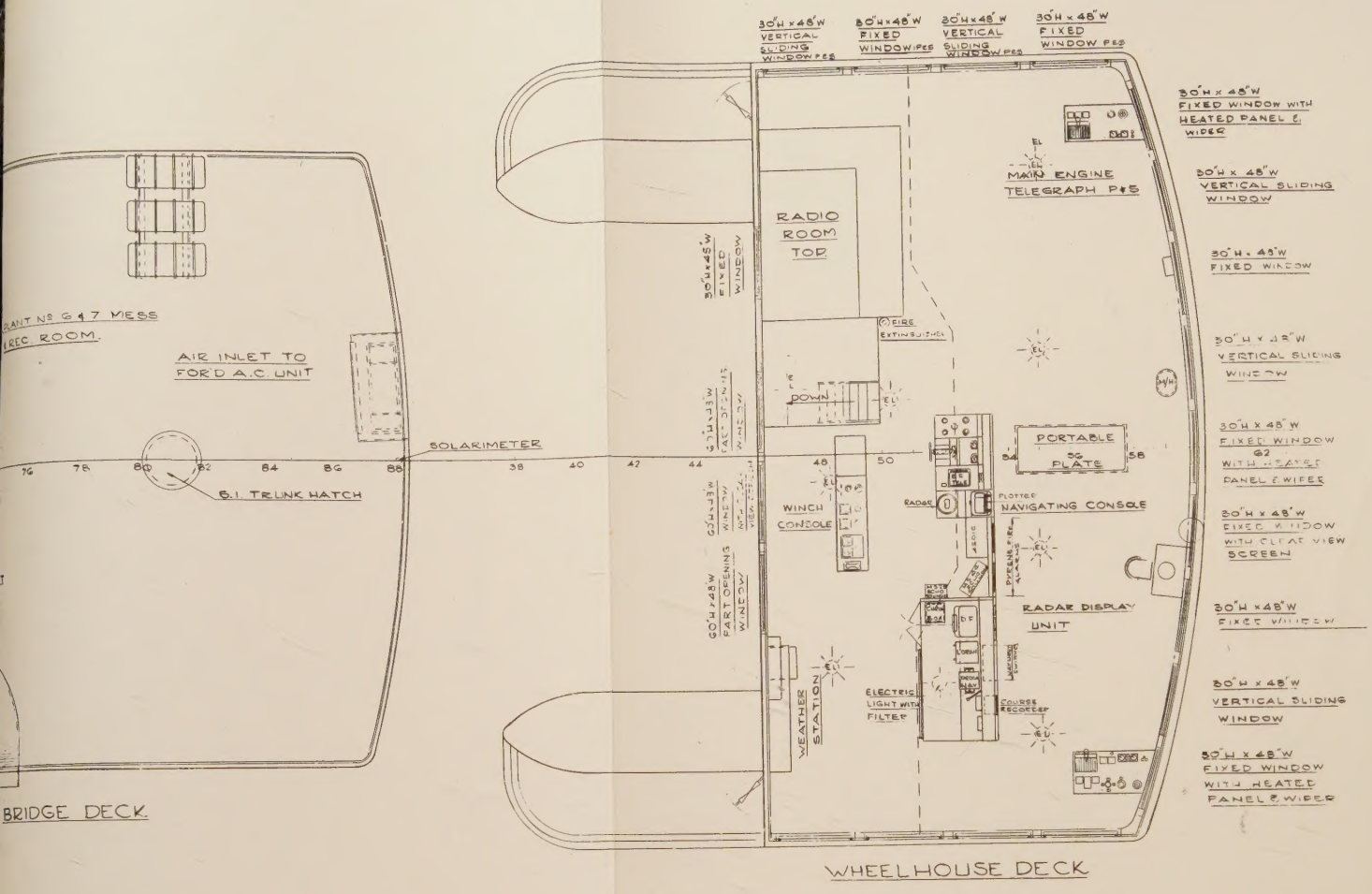
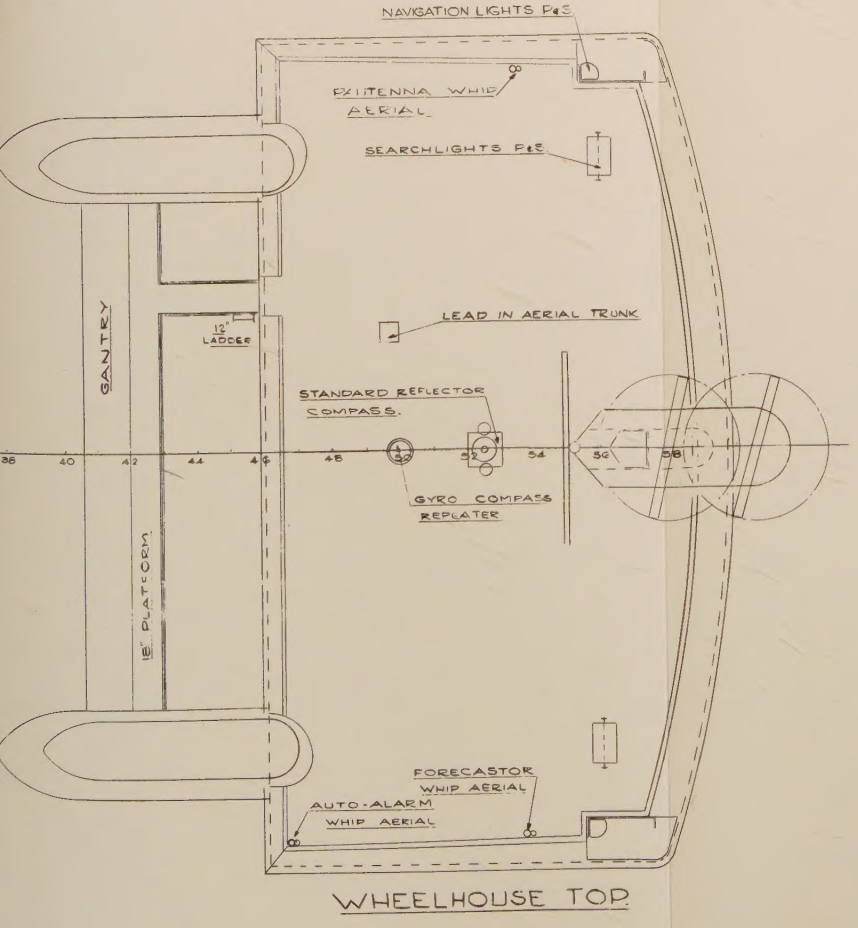
72
FIRE EXTINGUISHER
BATTERY ROOM
TANK
MANHOLE
MANHOLE
AIR INLET TO MIDSHIP A.C
GALLEY VENT TRUNK
9" DIA VIEWING PORT





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SCALE 1/4" = ONE FOOT	BUILDERS DRG Nº. 24
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FIG. 13 Plans of bridge, passive roll-stabiliser tank and radio room.